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ABSTRACT

The food science course developed in Missouri combines basic scientific and mathematics principles in a hands-on instructional format as a part of the family and consumer sciences education curriculum. Throughout the course, students conduct controlled experiments and use scientific laboratory techniques and information to explore the biological and chemical properties of food and its functions. The modules in this resource guide were developed to supplement instruction in the food science course. The guide contains nine modules that cover the following topics: (1) food science; (2) the scientific method; (3) organizations and resources; (4) food safety and sanitation; (5) HACCP (Hazard Analysis Critical Control Points); (6) Material Safety Data Sheets; (7) vitamins and minerals; (8) solutions; and (9) food additives. Each module contains some or all of the following components of a unit of instruction: overview, teacher background information, learning activities, laboratory experiments, "for teacher use" pages answers, questions and conclusions, assessments, and instructor sheets. (KC)

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Food Science

Content Modules for Food Science Featuring Problem-Solving Activities in Family and Consumer Sciences

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Food Science

Content Modules for Food Science Featuring Problem-Solving Activities in Family and Consumer Sciences

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Family and Consumer Sciences Education

Vision Statement:

To empower individuals and families across the life span to manage the challenges of living and working in a diverse, global society. Our unique focus is on families, work, and their interrelationships.

Mission Statement:

To prepare students for family life, work life, and careers in family and consumer sciences by providing opportunities to develop the knowledge, skills, attitudes, and behaviors needed for:

- ★ *strengthening the well-being of individuals and families across the life span;*
- ★ *becoming responsible citizens and leaders of family, community, and work settings;*
- ★ *promoting optimal nutrition and wellness across the life span;*
- ★ *balancing personal, home, family, and work lives;*
- ★ *using critical and creative thinking skills to address problems in diverse family, community, and work environments;*
- ★ *functioning as providers and consumers of goods and services;*
- ★ *appreciating human worth and accepting responsibility for one's actions and success in family and work life; and*
- ★ *successful life management, employment, and career development.*

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Food Science Competency List Crosswalked to the Missouri Show-Me Standards

Food Science Competencies	Missouri Show-Me Standards
A. Orientation to Food Science	
1. Compare and contrast food science to foodservice management	CA3, HP1, SC1
2. Utilize basic principles of measurement in scientific experimentation (e.g., metrics, formulas, and equations)	MA2, MA4
3. Demonstrate use, care, and safety of scientific lab equipment	SC7
4. Explain the steps in the scientific method	SC7
5. Write accurate and complete reports of science experiments	CA4
6. Identify the public and private organizations that influence food science, dietetics and nutrition industries	HP6, SS3, SS6
7. Identify career paths related to food science, dietetics and nutrition	CA3
B. Sensory Evaluation of Food	
1. Identify qualities that make up the sensory characteristics of food	SC1
2. Describe characteristics of sensory evaluation using appropriate terms	CA3, SC1
3. Determine characteristics that affect food preferences	HP2, SS6
C. Food Safety and Sanitation	
1. Compare the positive and negative effects of yeast, molds, bacteria and enzymes in foods	SC4
2. Identify principles of HACCP (assess hazards, identify critical control points, set up control procedures, monitor critical control points, take corrective actions, develop a recordkeeping system, verify that the system is working)	HP3, HP6, SC4, SC8
3. Describe the types of microorganisms that cause foodborne illness (e.g., bacteria, viruses, parasites, yeast, molds)	HP3, SC3
4. Explain the relationship between microorganisms and foodborne illness	HP3, SC3
5. Describe the basic environmental conditions that encourage the growth of microorganisms (e.g., time, temperature, moisture, oxygen)	SC3, SC4
6. Identify the three major types of hazards that cause foodborne illness (biological, chemical and physical)	HP6
7. Describe symptoms and causative agents of major foodborne illnesses (e.g., salmonellosis, botulism, hepatitis A)	HP3, HP6
8. Discuss how contamination and cross- contamination of foods can occur	HP3, HP6
9. Identify methods and procedures for controlling foodborne illness	HP3, HP6
10. Demonstrate personal hygiene/health practices essential for food safety and sanitation	HP2, HP3
11. Name typical products, tools and methods for effective cleaning and sanitizing	HP3, HP6
12. Identify location of and information on MSDS (Material Safety Data Sheets)	HP3, HP6

Food Science Competencies	Missouri Show-Me Standards
D. Science Foundations	
1. Demonstrate the effects of acids and bases in food metabolism, preparation, processing and preservation	SC1
2. Describe the classes of matter, including pure substances and mixtures	SC1
3. Identify the elements found in biochemical systems (food) and their atomic symbols	SC1
4. Explain the properties and principles of matter and energy (e.g., bonding, parts of the atom)	SC1
5. Identify components of a chemical equation	SC1
6. Differentiate between chemical reactions and physical changes in food	SC1
7. Demonstrate the relationship between energy, physical changes, and chemical reactions	SC1
8. Discuss the relationship between molecular motion and temperature	SC2
9. Explain how heat is transferred	SC1
10. Interrelate the effects of temperature, latent heat and phase changes	SC1
E. Biochemistry of Foods and the Major Nutrient Groups (Carbohydrates, Proteins, Lipids, Vitamins, Minerals and Water)	
1. Describe terms related to the major nutrients and nutrient groups	SC1
2. Describe the functions of the major nutrients and nutrient groups	SC1
3. Explain the functions of the major nutrients and nutrient groups in foods and food systems	SC1
4. Explain the process of sugar hydrolysis	SC1
5. Identify the product resulting from the hydrolysis of sucrose and lactose	SC1
6. Compare the structures of amylose and amylopectin and their effect on cooking properties	SC1
7. Discuss gelatinization, paste, retrogradation, and syneresis as they relate to starch cookery	SC1
8. Explain what occurs during denaturization	SC1
9. Describe the chemical structure of protein	SC1
10.Compare the properties of saturated and unsaturated fatty acids	SC1
11. Identify foods that contain saturated and unsaturated fats (trigylcerides)	SC1
12. Explain the differences between the types of fats and cholesterol	SC1
13. List ways lipid oxidation can be controlled in food	SC1
14. Explain the role of water in the formation of solutions, colloidal dispersions, and emulsions	SC1
15. Compare and contrast bound and free water in foods	SC1
16. Compare and contrast water soluble and fat soluble vitamins	HP2
17. Distinguish between major and trace minerals	HP2, SC1
18. Identify some interrelationships among nutrients (e.g., vitamin D and calcium)	HP2

Food Science Competencies	Missouri Show-Me Standards
19. Discuss the effect of food processing on vitamin and mineral levels in food	HP2, HP5, HP6
20. Relate metabolism to the factors that affect it	HP1, HP2
F. Chemistry of Food Formulations and Reactions	
1. Explain the relationships between enzymes, coenzymes and substrates	SC1
2. Identify factors that affect enzymatic activity	SC1
3. Distinguish the function of enzymatic reactions in food spoilage and food preparation	SC1
4. Identify the solvents and solutes in solutions	SC1
5. Analyze the effect of concentration on physical properties of a solution	SC1
6. Identify the properties of colloidal dispersions	SC1
7. Explain the relationship of an emulsion's parts	SC1
8. Explain the functions and properties of leavening agents	SC1
9. Identify the classes of food additives	HP6, SC8
10. Discuss the role of governmental regulations regarding food additives	HP6, SC8, SS3, SS6
11. Explain the use of additives in food	HP6, SC8
12. Discuss the risks and benefits of using additives in food	HP6, SC8
G. Food Manufacturing Processes (Fermentation, Canning, Freezing, Dehydration and Irradiation)	
1. Define terms related to food manufacturing processes	HP6, SC8
2. Identify commonly processed foods	HP6, SC8
3. Compare and contrast food manufacturing processes	HP6, SC8
4. Identify equipment used in food manufacturing processes	HP6, SC8

FOREWORD

The development of a course and accompanying resources for food science was undertaken in the 1996-97 school year through the Family and Consumer Sciences Education section of the Missouri Department of Elementary and Secondary Education. The intent of this course is to enable family and consumer sciences education students to gain an understanding of food and nutrition through the application of scientific principles. Utilizing an interdisciplinary approach, students achieve a greater variety of scientific experiences through a course that may also meet a science requirement for high school graduation.

Food Science combines basic scientific and mathematics principles in a relevant, hands-on instructional format as a part of the family and consumer sciences education curriculum. Throughout the course, students conduct controlled experiments and utilize scientific laboratory techniques and information to explore the biological and chemical properties of food and its functions. The food science course can also strengthen students' critical thinking, writing and reasoning skills necessary for life and work in today's society. These important skills are included in the Missouri Show-Me Standards, adopted by the Missouri State Board of Education in 1996.

When the statewide Food Science Advisory Committee met in the spring of 1997 to develop the student competency list for a semester food science course, they identified the following as potential instructional resources to support the identified competencies: *Food Science: The Biochemistry of Food and Nutrition, Third Edition,* a student text published by Glencoe/McGraw-Hill Publishing Co.; and *Food Science, Food Safety and Nutrition,* a curriculum for family and consumer sciences and agriculture education developed jointly by the National Council for Agriculture Education and FHA/HERO as a special project of the national FFA Foundation.

The modules in this resource guide were developed to supplement instruction in the food science course in addition to the resources noted previously. These modules utilize the practical problem solving approach found in Ohio's *Work and Family Life* curriculum. In each module, a practical problem related to food science is presented to support one or more competencies. Learning Activities, Classroom Experiences and additional Laboratory Experiments are provided which encourage students to use critical thinking and practical reasoning skills in pursuit of a solution or answer to the specific food science problem. Many of the activities and experiments presented in the guide also can be used as enrichment for students seeking additional study in food science concepts.

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Using the Food Science Modules

These modules were developed to help family and consumer sciences teachers provide instruction for selected competencies in the Food Science competency list. They are designed to supplement instruction along with several other current instructional resources for food science available to family and consumer sciences teachers, to include the Glencoe/McGraw-Hill student text, *Food Science: The Biochemistry of Food and Nutrition, Third Edition*, and *Food Science, Food Safety and Nutrition*, a curriculum guide for family and consumer sciences and agriculture education.

The modules utilize the critical science curricular approach. In this approach to learning, students use critical thinking and practical reasoning skills to "clarify personal and family issues, evaluate alternative choices and their consequences, develop criteria and standards for making ethical choices, and take action based on the consequences for self, family and others" (*Nutrition and Wellness Resource Guide, 1995*). More information about this curricular approach can be found in Ohio's *"Work and Family Life Program"* resource guides available from the Instructional Materials Laboratory at the University of Missouri-Columbia. Dr. Doug Holt, Associate Professor of Food Science and Nutrition at the University of Missouri-Columbia, served as a technical reviewer for this guide. He is available to teachers needing technical information in using these materials. He can be reached in the following ways:

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Students can utilize the modules to explore and research the answer or solution to problems related to food science and the food industry. These modules can also be used as enrichment activities for students seeking indepth insight into the concepts highlighted in the modules.

Information Provided in the Modules

Module Overview

Each module emphasizes a specific topic related to food science. Each topic addresses one or more of the student competencies identified for the course. These competencies are listed in the module overview, as well as concepts covered in the module that directly support the student competencies.

Teacher Background Information

This section provides information for the teacher to use in helping students understand the problem. A rationale is provided which explains why this topic is a practical problem and describes the importance of the issue to the food industry. In many of the modules, the background information supplements related topics found in the text *"Food Science: The Biochemistry of Food and Nutrition"* by K. Mehas and S. Rodgers. Reference information is provided at the end of this section for teacher use in obtaining additional information or directing students to other resources.

Learning Activities

Each **Learning Activity** assists students in mastering the competencies identified in the module. Activities are divided according to the supporting concepts noted in the module overview. For many of

the activities, **Discussion Topics** are provided which can be used in small- or large-group discussions. In some instances, there is no right or wrong answer, or several answers may apply. Answers for these questions can be found on the **For Teacher Use** page(s) within each module.

Several of the modules include laboratory experiments as **Learning Activities**. For each of these experiments, the **For Teacher Use** section provides information for the teacher on expected timeframes for conducting the experiment, materials and equipment needed or safety cautions.

The **Laboratory Experiment** pages can be copied and used as worksheets for the experiment or activity. These pages provide tables or other charts needed for gathering and reporting data related to the experiment and a section for recording specific instructions from the teacher under **Clean-Up Instructions**. A set of **Questions and Conclusions** for analyzing the results of the experiment and any subsequent findings also is included. Again, it is important to note that not all experiments may need to be used and some may be more beneficial to some students as enrichment activities.

Assessments

This section offers several methods to assess student learning. The assessments are categorized as either writing exercises, classroom experiences or real life applications. The teacher may choose to modify or adapt the suggested assessments. To enhance competency attainment, assessment criteria and performance expectations should be provided to students in advance of the assessment. Rubrics or checklists could be developed by the teacher and/or students for many of the activities provided.

Instructor Sheets

In addition to activities, experiments and assessments, some modules also contain **Instructor Sheets** which can be reproduced as student handouts or overhead transparencies for classroom instruction.

Module 1 Overview

Practical Problem:

What is the relationship between food science and foodservice management?

Competency:

A1 Compare and contrast food science to food management.

Supporting Concepts:

1. Food science and foodservice management

Teacher Background Information

Rationale

People are becoming more concerned about the foods they eat. They are interested in the food's nutritional content and its cost. Therefore, it is important to understand how the different ingredients of foods affect the body and ways this food can be processed to reduce the cost to consumers. In order to do this, research has to be conducted to determine how the different ingredients react with each other and how they react under different environmental conditions. Processing technology is being developed and modified to help reduce the cost of these items. Once this has been done, care needs to be taken to insure that consumers receive quality products.

Background

Mehas and Rodgers (1997) define food science as "the study of production, processing, preparation, evaluation and utilization of food" which encompasses "other areas of science such as chemistry, biology, physics, and psychology."

Foodservice management deals with the processes involved in preparing and serving foods to consumers, whether the foods are pre-made or made from scratch. According to Minor and Cichy (1984), these processes consist of planning, organizing, directing, staffing, controlling, and evaluating. Managers have to plan ahead for the number of customers they expect to serve, along with the operating costs and expected sales. Foodservice managers are responsible for organizing all available resources so that the goals and objectives of the company are met. Once these plans and objectives are organized, tools need to be utilized to direct these resources. Minor and Cichy indicate that work schedules, food preparation requirements, menus, and portion sizes are some of the tools food managers utilize. Employees are hired and trained according to the company's standards. Minor and Cichy define "controlling" as a comparison between how the company is expected to do and how the company actually does. Finally, evaluation of the company's performance is done to determine what corrective actions should be made in order for the company to reach its expected goals.

Foodservice involves producing edible and attractive food for consumers. Both food science and foodservice management have interrelated functions involved in preparing this food. The Instructor Sheets entitled **Food Science Steps** and **Foodservice Management Steps** describe the basic processes involved in creating and delivering food to the consumer. You can see how the two are similar and how they are different.

Food science and foodservice management try to work together. Food science helps to develop foods that are convenient and require little time to prepare and foodservice management makes sure the foods meet the consumer's satisfaction.

References

Mehas, K.Y. and Rodgers, S.L. Introduction to Food Science in *Food Science: The Biochemistry of Food and Nutrition.* 3rd ed., New York: Glencoe/McGraw-Hill, 1997. 14-17.

Minor, L.J. and Cichy, R.F. Foodservice Management in *Foodservice Systems Management.* Connecticut: AVI Publishing Company, Inc., 1984. 1-4.

Learning Activities

1. Food Science and Foodservice Management

a. Select a food product, some examples are given on the **Food for Thought** Instructor Sheet. Write down the steps required to make this product. Discuss which steps a food scientist would be involved with and which steps a foodservice manager would be involved with.

Discussion Topics:

What would be your responsibilities with this product if you were a food scientist?

What would be your responsibilities with this product if you were a foodservice manager?

How are these two jobs interrelated?

b. Working in groups, choose a product and write the ways a food scientist would be involved with this product and the ways a foodservice manager would be involved with this product.

Discussion Topics:

What would be your responsibilities with this product if you were a food scientist?

What would be your responsibilities with this product if you were a foodservice manager?

How are these two jobs interrelated?

Assessment

Paper and Pencil

1. Create a flow diagram which shows how food science and foodservice management are similar and different.

Classroom Experiences

1. Choose a snack food and list all steps that are involved in making this product ready for consumption and who would be responsible for these different activities.

Food For Thought

Tortilla Chips

Food Scientist

Inspect and store raw ingredients
Produce the chips
Ensure a quality product
Test to ensure chips were cooked correctly
Package chips properly
Distribute to vendors

Foodservice Manager

Inspect and store raw ingredients
Cook the chips
Ensure quality product will be served
Check to make sure chips were prepared correctly
Place chips in a basket
Serve the chips to customers

Cheese Cake

Food Scientist

Inspect and store raw ingredients
Produce cheese cake
Ensure a quality product
Test to ensure cheese cake was cooked correctly
Package cheese cake and refrigerate
Distribute to vendors

Foodservice Manager

Inspect and store raw ingredients
Cook and refrigerate cheese cake
Ensure quality product will be served
Check to ensure cheese cake was prepared correctly
Place cheese cake on plate
Serve cheese cake to customers

Food For Thought

Dinner Rolls

Food Scientist

Inspect and store raw ingredients
Produce dry mix
Prepare dough
Bake rolls
Ensure quality product
Test to ensure rolls were cooked correctly
Package rolls properly
Distribute to vendors

Foodservice Manager

Inspect and store raw ingredients
Prepare dough
Bake rolls
Ensure quality product will be served
Check to make sure rolls were prepared correctly
Place rolls in basket
Serve rolls to customers

Cookies

Food Scientist

Inspect and store raw ingredients
Produce dry mix
Prepare dough
Bake cookies
Ensure quality product
Test to ensure cookies were cooked correctly
Package cookies properly
Distribute to vendors

Foodservice Manager

Inspect and store raw ingredients
Prepare dough
Bake cookies
Ensure quality product will be served
Check to make sure cookies were prepared correctly
Place cookies on plate
Serve cookies to customers

Steps for Creating and Delivering Foods to the Consumer

Food Science Steps	
1	Inspect & Store Ingredients
2	Process
3	Test Quality Assurance • Safe • Consistent • Able to be prepared or finished correctly
4	Package
5	Distribute

Foodservice Management Steps	
1	Store Ingredients
2	Prepare & Cook
3	Test Quality Assurance Through Inspection • Look • Smell • Taste
4	Present
5	Serve

Module 2 Overview

Practical Problem:

How and why is the scientific method used in the food, dietetic and nutrition industries?

Competency:

A4 Explain the steps in the scientific method.

Supporting Concepts:

1. Terms related to the scientific method.
2. The steps in the scientific method.
3. How to use these steps.

Teacher Background Information

Rationale

Scientific discoveries are made every day. It is important that these discoveries are documented and published. A scientific approach is needed to ensure these discoveries are conducted under specific conditions, producing accurate results that will be accepted by other scientists. By making this knowledge available to others, principles involved in other systems may get discovered.

Food scientists use the scientific method to solve everyday problems that arise in the work place. They use it when developing new products, improving existing products, determining proper packaging and storage conditions, and calculating the nutritional content of food.

Background

Wallace *et al* (1981) defines the scientific method as, "the process of establishing new facts and understanding mechanisms." It consists of a series of steps used to prove or disprove a solution to a problem. There are several terms that need to be explained in order to understand the steps involved in conducting and writing a scientific method.

Hypothesis is an educated guess or idea about how the problem should turn out.

Variable is any part of the experiment that can be changed.

Control Environment is the experiment without a change in any variable.

Experimental Environment is the experiment with variables changed.

Theory is an explanation of a natural event based on the results of an experiment.

The first step is to try to answer the question "why." A problem is chosen in which an experiment can be performed to determine how or why a situation occurs. Then resources are identified that are available to gather information about the problem.

An hypothesis is formed to help explain the facts. The hypothesis must "make predictions and it must be testable" (Wallace *et al*, 1981). This hypothesis must now be tested by an observation. This can be done by conducting research. Specified conditions are used in setting up this experiment and; "the

experiment should be designed to test only one variable at a time" (*Food Science Experiment and Activity Guide*). The "variable" that is being observed needs to be examined to determine the relationship with the controlled variable. This allows for comparisons between the two systems, to make sure no alternative explanation for this observation exists. During the experiment, the data from this observation period needs to be recorded in a journal.

The results from the experiment need to be interpreted and a conclusion drawn. The results will either agree with the hypothesis or disagree with it. When the hypothesis is proved false, another hypothesis is required. One which will support the data that was collected. Once the hypothesis supports the data, more testing will be required to make sure the hypothesis holds true every time.

Finally, the information needs to be published in a scientific article. This allows the whole "scientific community" access to the findings and explains how the experiment was performed for those people conducting similar research.

From the results of the experiment, a theory can be proposed. A theory helps explain the problem that was investigated.

References

Food Science Experiment and Activity Guide. Raleigh, NC: North Carolina Department of Public Instruction, 1994.

Wallace, R.A., King, J.L., and Sanders, G.P. Mr. Darwin and the Meaning of Life in *Biology of Life*. California: Goodyear Publishing Company, Inc. 1981. 8-9.

Learning Activities

1. Terms related to the scientific method

Define: hypothesis, variable, control environment, experimental environment, and theory.

Discussion Topics:

Identify examples of each term.

2. The steps in the scientific method

Use Instructor Sheet **Scientific Method**. Identify the steps and use one of the problems on the **Experimental Problems** Activity Sheets to demonstrate these steps.

Teacher Note: The information contained in each **Experimental Problem** Instructor Sheet sets up a practical problem that a food scientist might face. The data provided represents the results that a food scientist might obtain if actual experiments were conducted. The information is provided to help students work through the problem to select a solution. You should not hand out the sheets to the students giving them the situation and the data together. First, read the situation to the students and let them think through the problem to form an hypothesis. Then provide the sample data as a handout, overhead transparency or by writing the data on the chalkboard and discuss.

Discussion Topics:

What are some problems a food scientist might encounter?

Identify resources needed to help gather information about the problem.

Can scientists change their hypotheses if they are proved wrong?

How can scientists determine if the data is valid?

What is the difference between a controlled environment and an experimental environment?

In what journals can food science research be found?

3. **How to use these steps**

Give the students a fictitious problem from the **Experimental Problems** Activity Sheet and have them use the seven steps of the scientific method to solve each.

Discussion Topics:

Identify the problem.

What resources are available to help in gathering data?

State possible hypothesis(es).

What do the data indicate?

Are other data needed?

Is there enough information to draw a conclusion?

Explain your conclusion.

State the theory related to this problem.

Assessment

Paper and Pencil

1. Devise a laboratory report that incorporates one of the **Experimental Problems**. (Use the laboratory report format on page 30 in *Food Science: The Biochemistry of Food and Nutrition* by Mehas and Rodgers.

Classroom Experiences

1. Select one of the **Experimental Problems** and list alternative solutions to that problem.

Application to Real-life Settings

1. Determine how each of the **Experimental Problems** relates to consumers.

Instructor Sheet

Scientific Method

Scientific Problem-solving Method

1. **State the Problem**

   Write a statement describing the problem you want to solve. The problem is usually written as a question.

2. **Gather Information**

   Identify resources that are available to gather information about the problem.

3. **Form an Hypothesis**

   An hypothesis is an educated guess or your idea about the answer to the question in Step 1. (Use information gathered in Step 2 to form an idea or educated guess about the answer to the question in Step 1.)

4. **Collect Data through Experimentation**

   An experiment is a test of your hypothesis. However, to be sure that your experimental results are valid, you must follow certain guidelines in performing the experiment.

   a. The experiment is usually designed to test only one variable at a time. A variable is defined as any part of the system that can be changed.

   b. The variable that is being changed has to be compared to the system without a change in the variable. This unchanged system is called the control.

   c. During the experiment, careful observations must be made and the same measurements taken for both the experimental and the control systems.

5. **Analyze Data and Form a Conclusion**

   By examining the results of your experiment, you should be able to conclude whether or not the experimental results agree with your hypothesis. If they do not support your hypothesis, you need to form a new hypothesis and perform another experiment. If your experiment does support your hypothesis, you usually confirm your hypothesis with several more tests. If your hypothesis still seems true, you can go to the next step of the Scientific Method.

6. **Report Results**

   Share results with the other people who understand the system you studied. These pople are sometimes called the scientific community.

7. **Propose a Theory**

   A theory explains the results of your experimental investigations by using fundamental scientific principles. In other words, how did the results happen?

Adapted from: Food Science Experiment and Activity Guide. ***Raleigh, NC:*** *North Carolina Department of Public Instruction, 1994.*

Instructor Sheet

Experimental Problems

Storage Conditions

Situation:

At Oscar Meyer, they are trying to determine the environment inside the packaging of pork frankfurters. Should they use carbon dioxide (CO_2), nitrogen (N_2) or vacuum package them? Since you are their Quality Assurance Manager, they want you to determine which method will provide the longest shelf-life. You set up an experiment to test the microbial count on the frankfurters for each one of these.

Data:

Months	CO_2	N_2	Vacuum
1	10	8	5
2	50	35	27
3	75	60	45

(A microbial count more than 50 means that the frankfurters could give you food poisoning.)

Package Permeability

Situation:

You are working for Frito Lay and you are in charge of shelf-life and packaging. The new potato chip "Zestes" has a shelf-life of only two weeks. Your boss insists that you extend the shelf- life to at least four weeks. You decide that the packaging allows too much moisture to be absorbed causing the "Zestes" to become stale. You decide to try some different types and thicknesses for the plastic (polymer) sleeves to see if they will extend the shelf-life. You test the rate at which water can travel through these different polymers. You are presently using a plastic sleeve made from Cryovac D-940 film.

Data:

Week	Cryovac BDF-100 film	Cryovac D-955 film	Cryovac D-940 film
1	0.198	0.339	0.476
2	0.326	0.508	0.689
3	0.461	0.849	0.849
4	0.597	0.947	0.967

(A moisture reading under 0.600 will allow "Zestes" to remain fresh for a month.)

Experimental Problems

Gums (Polysaccharides)

Situation:

You are the chemist for Kraft. Their research and development team is developing a honey Dijon sauce. They are trying to decide which gum should be used in order to get the spreadable consistency they require. Consumer research and chemical tests indicate a viscosity of 450,000 to 460,000 centipoise would produce a desirable viscosity. Several different batches were created with different gums and you test each of them using a viscometer.

Data:

	Viscometer Reading in Centipoise
Gum Arabic	
Sample 1 at 5 %	2,550
Sample 2 at 10 %	2,650
Sample 3 at 15 %	3,000
Carrageenan	
Sample 1 at 5 %	457,000
Sample 2 at 10 %	905,000
Sample 3 at 15 %	1,540,000
Xanthan Gum	
Sample 1 at 5 %	456,000
Sample 2 at 10 %	809,000
Sample 3 at 15 %	2,045,000

Experimental Problems

Total Fat Extraction

Situation:

In the past "total fat" was determined by extracting all lipids from the source and assuming this equaled the total fat content of the food. Since not all lipids are utilized by the body for energy, the NLEA (The Nutritional Labeling and Education Act of 1990) has defined the term "total fat" to be the sum of lipid fatty acids expressed as triglycerides (TG) (Code of Federal Regulations, 1994). You are the chemist for Pillsbury. They have asked you to determine which new method they should use in determining the total fat content of their cake mixes. Since there are several different methods that can be used, you do some research and narrow it down to two different methods. Acid hydrolysis measures the fat acidity which represents the amount of fatty acids that are hydrolyzed from triglycerides (Nielson, 1994). Saponification number uses an alkali to break down fatty acids into glycerol (Nielson, 1994). You decide to test both of these methods for accuracy and repeatability using one cake mix for all tests in your lab.

Data:

Cake Mix	Acid Hydrolysis Method	Saponification Number Method
Reference	282% FFA (as oleic)	4808 average M.W. of TG
1	290% FFA (as oleic)	4809 average M.W. of TG
2	275% FFA (as oleic)	4808 average M.W. of TG
3	269% FFA (as oleic)	4807 average M.W. of TG
4	281% FFA (as oleic)	4809 average M.W. of TG

(FFA = free fatty acids, M.W. = molecular weight)

References

Nielsen, S.S. Fat Characterization in *Introduction to the Chemical Analysis of Foods* (O.A. Pike), Boston: Jones and Bartlett Publishers. 1994. 195-200.

Code of Federal Regulations (CFR). Title 21, Parts 100-169, revised as of April 1994; 101.9; Washington, DC: United States Government Printing Office, 1994. 28-29.

For Teacher Use - Solutions to Experimental Problems

Storage Conditions

Problem: What type of gas, if any, should be used when packaging pork frankfurters.

Resources: Journals such as Journal of Food Science, Food Chemistry, and Journal of Food Processing and Preservation.

Magazines such as Food Microbiology, Food Processing, and Food Technology.

Hypothesis: CO_2 (N_2, Vacuum) will provide the longest shelf-life.

Analyze Data: Vacuum packed provided a shelf-life of 3 months. Nitrogen gas provided a shelf life of more than 2 months but less than 3 months and carbon dioxide only provided a shelf-life of 2 months.

Conclusion: The pork frankfurters should be vacuum packaged.

Theory: The amount of oxygen present in the environment affects which types and how many microorganisms will grow.

Package Permeability

Problem: Need to extend the shelf-life of "Zestes" to four weeks or more.

Resources: Companies that sell packaging materials.

Journals such as Journal of Food Science and Journal of Food Quality.

Magazines such as Food Engineering, Food Technology and Baking & Snacks.

Hypothesis: Different packaging materials will increase the shelf-life.

Analyze Data: Cryovac BDF-100 film provided the best protection. Cryovac D-955 film and Cryovac D-940 film would not be sufficient packaging materials.

Conclusion: The packaging material does affect the shelf-life of a product.

Theory: The permeability of the polymer determines the rate of increase in the water activity, inside the package.

For Teacher Use - Solutions to Experimental Problems

Gums (Polysaccharides)

Problem:	Which gum is best to use in the honey Dijon sauce to make it spreadable?
Resources:	Journals such as Journal of Food Science, Food Chemistry, Journal of Agricultural and Food Chemistry. Magazines such as Food Technology, Food Ingredients and Analysis International, and Food Processing. Official Methods such as Official Methods of Analysis (AOAC), American Association of Cereal Chemists.
Hypothesis:	The 5% 10%, 15% level *{choose one}* will produce a spreadable product; or Gum Arabic (Carrageenan, Xanthan Gum) will produce a spreadable product; or Gum Arabic at 5% will produce a spreadable product (or any of the other combinations).
Analyze Data:	Both, Carrageenan at 5% and Xanthan at 5%, will produce a spreadable product.
Conclusion:	Carrageenan at 5% and Xanthan at 5% can be used to make the honey Dijon sauce.
Theory:	The type and amount of similar ingredients can have varying effects.

Total Fat Extraction

Problem:	Which method to use for total fat as defined by NLEA.
Resources:	Journals such as Journal of Food Science, Journal of Agricultural and Food Chemistry, and Journal of Food Composition and Analysis. Magazines such as Food Reviews International, Food Ingredients and Analysis International, and Food Technology. Official Methods such as Official Methods of Analysis (AOAC), American Association of Cereal Chemists.
Hypothesis:	Acid hydrolysis will be the better method, or Saponification number will be the better method.
Analyze Data:	The saponification number was the most accurate and repeatable. Acid hydrolysis was not very accurate or it was hard to keep consistent with this method.
Conclusion:	Saponification Number Method will be the method Pillsbury uses for their cake mixes.
Theory:	The type of method used will depend on the food.

For Teacher Use - Solutions to Experimental Problems

Answers to Learning Activities

2. (a.) What are some problems a food scientist might encounter?

New product development
Improving products
Improving or developing processing methods
Ways to analyze the content of the food
Packaging conditions
Storage conditions

Identify resources needed to help gather information about the problem.

Journals, magazines, and companies

Can scientists change their hypothesis if it is proved wrong?

Yes

How can scientists determine if the data is valid?

- Was only one variable tested*
- Was a control used
- Are the results repeatable

What is the difference between a controlled environment and an experimental environment?

Controlled environment is the experiment without a change in any variable.

Experimental environment is the experiment with one or more variables changed.

In what journals can food science research be found?

Journal of Food Science, Food Chemistry, Journal of Food Engineering, Journal of Process Engineering, Journal of Agricultural and Food Chemistry, Journal of Sensory Studies, and Journal of Food Processing and Preservation. (There are many more.)

* While fine for student experiments, if the students look at the scientific literature they will seldom see single-variable experimental designs. Most frequently multi-variable or even more complex experimental designs are employed.

Module 3 Overview

Practical Problem:

How do organizations influence food science, dietetics and nutrition industries?

Competency:

A6 Identify the public and private organizations that influence food science, dietetics and nutrition industries.

Teacher Background Information

Rationale

Industries are governed and influenced by all kinds of organizations. These organizations can be private or public organizations. Government organizations provide rules and regulations under which industries have to operate. Trade organizations influence the direction in which the industry will follow. There are also professional organizations which assist food scientists, dietitians and nutritionists with their careers, publications of their work and business contacts. It is important to understand which organizations influence these industries and how these organizations can provide assistance to them.

Background

There are several thousand organizations that influence food science, dietetics and nutrition industries. Some of the more important ones are listed below.

- Public Organizations or Agencies -

American Council on Science and Health (ACSH) - Provides information to consumers on food, nutrition and health issues.

Environmental Protection Agency (EPA) - A government organization responsible for protecting the environment. Establishes federal standards for air quality and waste pollutants.

Food and Agriculture Organization, United Nations (FAO) - Works to prevent "hunger" worldwide. They help nations with "food preservation," engineering plants to "grow faster" and produce better crops.

Food and Drug Administration (FDA) - Administers laws to ensure food is produced under sanitary conditions and that the food presents no health hazards to consumers.

National Institute of Standards and Technology (NIST) - Provides necessary services for accurate and uniform measurements. Works with other organizations to provide test methods and reference standards.

National Marine Fisheries Service (NMFS) - Concerned with the living resources of the sea as they affect the U.S. economy and diet.

US Bureau of Alcohol, Tobacco and Firearms (ATF) - Enforces federal laws and regulations relating to alcohol.

US Customs Service - Insure that all goods entering and exiting the United States do so in accordance with all United States laws and regulations.

United States Department of Agriculture (USDA) - A government agency responsible for aspects pertaining to agriculture. Responsible for carrying out the legalities of statutes which pertain to food processing.

- Private Organizations -

American Association of Cereal Chemists (AACC) - Publishes books and articles related to cereal grains. Provides reference samples.

American Dairy Science Association (ADSA) - Provides analytical methods and technology aimed at advancing the dairy industry.

American Dietetic Association (ADA) - Provides guidance and publications on foods and nutrtion.

American Institute of Baking (AIB) - Provides a wide range of services to the baking industry such as training, publications, nutritional labeling, consulting and research.

American Society for Clinical Nutrition (ASCN) - Facilitates and promotes the issuing of credentials for practitioners of clinical nutrition. Implements public policies, expands research opportunities and publishes a journal.

American Society for Nutritional Sciences (ASNS) - Fosters and enhances research in animal and human nutrition.

Association of Official Analytical Chemistry (AOAC) - Develops and validates chemical and microbiological analytical methods.

Center for Science in Public Interest (CSPI) - An organization interested in improving the safety and nutritional quality of food.

Institute of Food Technologists (IFT) - A nonprofit organization designed to improve "the food supply and its use."

Institute of Food Science and Technology (IFST) - Provides assistance to food scientists in areas such as "safe, wholesome, nutritious and attractive food."

International Association of Food Industry Suppliers (IAFIS) - Hosts food shows that bring buyers and sellers together. IAFIS provides information and assists in research related to the food industry.

International Dairy Foods Association (IDFA) - An organization involved with legislation and research in the dairy industry.

International Food Information Council - Provides scientific information obtained from the food industry and health professionals to the public regarding food safety and nutrition.

National Beef Industry Council - A trade association involved in marketing, research, education, legislative initiatives and activities of the cattle industry.

National Meat Association (NMA) - Involved in legislation pertaining to the meat industry.

National Pork Producers Council (NPPC) - Involved in research and technology pertaining to the pork industry.

Poultry Science Association (PSA) - Aids in the discovery, application and publication of knowledge related to poultry science.

US Poultry and Egg Association - Tries to improve the quality and safety of poultry products by performing research and educating the poultry industry.

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ADA. American Dietetic Association. Online. Internet. 17 Nov. 1997.
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AOAC. Association of Official Analytical Chemistry. Online. Internet. 17 Nov. 1997.
http://www.aoac.org/
ASCN. American Society for Clinical Nutrition. Online. Internet. 17 Nov. 1997.
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ATF. Bureau of Alcohol, Tobacco, and Firearms. Online. Internet. 17 Nov. 1997.
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PSA. Poultry Science Association. Online. Internet. 17 Nov. 1997.
http://www.psa.uiuc.edu/
U.S. Customs Service. Online. Internet. 17 Nov. 1997.
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US Poultry and Egg Association. Online. Internet. 17 Nov. 1997.
http://www.poltryegg.org/

Learning Activities

1. Organizations

a. Contact one of the organizations or agencies listed on the **Food Science Organizations** Instructor Sheet. (Try using the Internet.) Give an oral presentation to the class about your findings.

Discussion Topics:

Describe the function of this organization.

What is the organization's mission statement?

How is this organization involved in the food science, dietetics or nutrition industry?

What is the difference between a trade association and a consumer organization?

b. Fill in the **Organizations and Functions** worksheet by working in cooperative groups.

Discussion Topics:

Which organizations have similar functions?

How do these organizations benefit you as a consumer?

How do these organizations benefit food scientists, dietetics and nutrition industry professionals?

Assessment

Classroom Experiences

1. Use the Internet to find information on the different public and private organizations and agencies to determine whether they serve consumers or the industry, how many members they have, or the organization's mission.

2. Give an oral presentation about an organization that influences food science.

Application to Real-life Settings

1. Contact an organization that has an influence on food science. Explore how the organization benefits the industry. How does the organization affect consumers?

2. Point out ways these organizations benefit you as a consumer by designing a bulletin board display for a local grocery store.

Instructor Sheet

Food Science Organizations

Public Organizations & Agencies

American Council on Science and Health (ACSH)

Food and Agriculture Organization, United Nations (FAO)

Food and Drug Administration (FDA)

The National Marine Fisheries Service (NMFS)

United States Department of Agriculture (USDA)

US Bureau of Alcohol, Tobacco, and Firearms (ATF)

US Customs Service

National Institute of Standards and Technology (NIST)

Environmental Protection Agency (EPA)

Private Organizations & Agencies

Association of Official Analytical Chemistry (AOAC)

American Association of Cereal Chemistry (AACC)

American Dairy Science Association (ADSA)

American Dietetic Association (ADA)

American Institute of Baking (AIB)

American Society for Clinical Nutrition (ASCN)

American Society for Nutritional Sciences (ASNS)

Center for Science in Public Interest (CSPI)

Institute of Food Technologists (IFT)

Institute of Food Science and Technology (IFST)

International Association of Food Industry Suppliers (IAFIS)

International Dairy Foods Association (IDFA)

International Food Information Council

National Meat Association (NMA)

National Pork Producers Council (NPPC)

Poultry Science Association (PSA)

US Poultry and Egg Association

Activity Sheet

Organizations & Functions

RESEARCH RESOURCES

Name: _____ Date: _____

Directions: Use the library, Internet or other resource to look up each of the following groups. Place an X in the column that describes the role or function of the organization.

Organization	Analytical Methods	Regulations and Laws	Publications	Reference Standards	Food Supplies	Research
American Dietetic Assn						
American Assn of Cereal Chemists						
American Dairy Science Assn						
American Society for Clinical Nutrition						
American Society for Nutritional Sciences						
American Institute of Baking						
American Council on Science and Health						
Assn of Official Analytical Chemistry						
Center for Science in the Public Interest						
Environmental Protection Agency						
Food and Agriculture Organization						
Food & Drug Administration						
Institute of Food Science & Technology						
Institute of Food Technologists						
International Assn of Food Industry Suppliers						
Int'l Dairy Foods Assn						
National Marine Fisheries Service						
National Institute of Standards & Technology						
Nat'l Meat Assn						
Poultry Science Assn						
US Bureau of Alcohol, Tobacco & Firearms						
US Customs Service						
US Dept. of Agriculture						

For Teacher Use - Organizations & Functions

Answers to **Organizations and Functions** Activity Sheet.

Organization	Analytical Methods	Regulations and Laws	Publications	Reference Standards	Food Supplies	Research
American Dietetic Assn		X	X			
American Assn of Cereal Chemists	X		X	X		
American Dairy Science Assn	X		X			
American Society for Clinical Nutrition		X	X			X
American Society for Nutritional Sciences			X			
American Institute of Baking			X			X
American Council on Science and Health		X	X			X
Assn of Official Analytical Chemistry	X		X			
Center for Science in the Public Interest		X	X			
Environmental Protection Agency		X	X			
Food and Agriculture Organization			X			X
Food & Drug Administration		X	X			
Institute of Food Science & Technology			X			X
Institute of Food Technologists			X		X	X
International Assn of Food Industry Suppliers			X		X	X
Int'l Dairy Foods Assn		X	X		X	X
National Marine Fisheries Service		X	X	X		
National Institute of Standards & Technology		X	X			X
Nat'l Meat Assn		X	X			
Poultry Science Assn			X			X
US Bureau of Alcohol, Tobacco & Firearms		X	X			
US Customs Service		X				
US Dept. of Agriculture		X	X			

Module 4 Overview

Practical Problem:

What should I do about food safety and sanitation?

Competencies:

C1 Compare positive and negative effects of yeasts, molds, bacteria and enzymes in foods.

C4 Explain the relationship between microorganisms and foodborne illness.

C5 Describe the basic environmental conditions that encourage the growth of microorganisms (e.g., time, temperature, moisture and oxygen).

C6 Identify the three major types of hazards that may cause foodborne illness (biological, chemical, and physical).

C7 Describe symptoms and causative agents of major foodborne illnesses (e.g., salmonellosis, botulism, hepatitis A).

C8 Discuss how contamination and cross-contamination of foods can occur.

C9. Identify methods and procedures for controlling foodborne illness.

C10 Demonstrate personal hygiene/health practices essential for food safety and sanitation.

C11 Name typical products, tools and methods for effective cleaning and sanitizing.

Supporting Concepts:

1. Foodborne illnesses and contamination
2. Food handling practices and sanitation applications in food manufacturing/food processing/food preparation
3. The foods you eat

Teacher Background Information

Rationale

The conditions under which food is processed and manufactured determines how safe the food will be for consumption. If food is allowed to get contaminated before, during or after processing and steps are not taken to reverse this damage, then foodborne illnesses may develop. Some microorganisms are toxic chemicals or parasites that can produce foodborne illnesses. Microorganisms can cause chemical and physical changes to food. Sometimes this is desirable, as in bread or yogurt making. Other times the food will spoil. Occasionally disease-causing microorganisms will grow which could cause food-borne illness. If food is handled properly and stored correctly, foodborne illnesses can be prevented.

Background

Food safety is an important job for employees when processing or preparing food to be sold to the consumer. Food safety is concerned with foodborne illnesses, personal hygiene, sanitation and contamination. The Educational Foundation of the National Restaurant Association published *Serving Safe Food* which states that food safety protects you, consumers and co-workers; is a requirement by law; and is good business.

There are three major types of hazards that can cause foodborne illnesses. They are biological, chemical and physical. Biological hazards consist of metabolic reactions that occur during harvesting and storage. These metabolic reactions consist of microbiological, enzymatic and chemical reactions. Chemical hazards consist of the different cleaning agents used during sanitation practices or pesticides applied to raw products. Physical hazards consist of foreign objects that are not normally present in the food. Examples of physical hazards would be broken glass, metal, paper or plastic (*Serving Safe Food*).

Yeast, molds, bacteria and enzymes have both beneficial and detrimental effects in food. They provide flavor, taste and texture to food. Talaro and Talaro (1993) indicate that microorganisms provide "leavening," "flavor," "odor" and "conditioning" to bread dough. Yeast, molds and bacteria provide the necessary enzymes required to ferment vegetables which are used in oriental foods such as soy sauce, tofu and tempeh. Bacteria are added to milk to make cheese and yogurt. Alcoholic beverages are made from the fermentation process of yeast.

There are two types of microbial contamination in food, spoilage bacteria and bacterial pathogens. Spoilage bacteria cause chemical changes in food. Several different types of microorganisms exist naturally in food. These organisms consume the nutrients present in the food and produce waste products. The waste products provide changes in the chemical composition of the food by changing the pH, producing off-flavors and off-odors. These changes will not necessarily cause people to become ill if they consume them, however they make the food unappealing to customers.

Pathogenic bacteria produce toxins which are harmful to people. These bacteria may or may not exist naturally in the food. Steps need to be taken to prevent them from entering food sources and reproducing in them. If proper environmental conditions exist in the food, these organisms can grow and reproduce causing foodborne illnesses.

Several different environmental conditions affect the growth of microorganisms. These are the food item, temperature, moisture, oxygen, pH and time. The chemical composition of the food determines which microorganisms can survive and reproduce in it. Certain elements are required for bacteria to flourish. Some of these are carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. Others are also required depending on the microorganism.

Microorganisms grow and reproduce in certain temperature ranges. The optimum temperature for a microorganism is the temperature at which growth is most rapid. Some require cold temperatures, below 15°C (psychrotrophs); others prefer hot temperatures, above 45°C (thermophiles) and most of them prefer moderate temperatures, 20° - 40°C (mesophiles). Microorganisms can survive at temperatures outside of their optimum temperature; however, they will not grow or reproduce.

Water is required by all organisms for growth. Different types of microorganisms require different amounts of moisture. Molds can survive in low-water content foods; whereas, bacteria require a high water content.

Microorganisms are classified as either aerobic (require oxygen) or anaerobic (require no oxygen). Most organisms fall somewhere in between these extremes. Some aerobic organisms can grow in anaerobic conditions and some anaerobic organisms can grow in aerobic conditions.

Microorganisms have an optimum pH range which allows them to grow the best. Most bacteria grow the best in neutral pH conditions. Yeast and molds thrive under acidic conditions.

The amount of time the microorganisms are allowed to grow and reproduce also is a factor. If food is handled for long periods of time or not stored properly, then microorganisms have time to grow and reproduce.

The Educational Foundation of the National Restaurant Association (EFNRA) defines foodborne illness as any "disease that is carried or transmitted" through food (*Serving Safe Food*). People can get foodborne illnesses from ingesting food that has been contaminated from toxic chemicals, parasites and their eggs, or microorganisms.

Microbial foodborne illnesses can be of two types: food intoxication or food infection. Both of these are referred to as food poisoning. Food intoxication is where microorganisms grow and reproduce in food. The microorganisms are destroyed during processing but the toxins that are secreted are not destroyed. When these toxins are ingested, they disrupt specific systems in the body. The symptoms of food intoxication can vary from vomiting and diarrhea to disrupted muscle function. Botulism and gastroenteritis are both caused from food intoxication.

Botulism is caused from *Clostridium botulinum.* It causes paralysis of breathing muscles by blocking the nervous impulses to them. Death often results from this foodborne illness; however, this illness is rare). Symptoms occur 12 - 72 hours after consumption of the toxin. This microorganism is found in commercial and home canned vegetables.

Staphylococcal gastroenteritis is caused from *S. aureus* and other species. According to Christie and Christie (1977), the main symptom of gastroenteritis is vomiting, while abdominal pain is more uncommon. If diarrhea occurs, it will not be severe. This foodborne illness lasts about 1-2 days. This microorganism is found in animal products.

Food infection involves the microorganism growing and reproducing in the food. The organism itself attacks the body. The symptoms of food infection are diarrhea and abdominal pain. These symptoms can be caused from toxins produced by the microorganisms while they are living in the body. Food infections include salmonellosis, dysentery and *E. coli.*

Salmonellosis is caused from several different *Salmonellae* species. According to Christie and Christie (1977), the main symptom of Salmonellosis is diarrhea with vomiting being uncommon unless the food is heavily contaminated. This illness lasts about two days. This microorganism is found in eggs, poultry and meats.

Bacillary dysentery is caused from *Shigellae.* It is spread by direct or indirect contact with humans. This microorganism can be carried in shellfish, vegetables, fruits, chicken and salads.

There are several different strains of *Escherichia coli.* These strains cause two types of foodborne illnesses. Hemorrhagic colitis is characterized by bloody diarrhea and abdominal pain with the symptoms lasting 3-7 days. *E. coli* 0157:H7 belongs to this type. Travelers' diarrhea causes watery diarrhea that is associated with traveling to different countries. These microorganisms can be found in creamed foods, mashed potatoes and meats.

Viruses are parasitic organisms that cannot survive without a host and they are very specific for their host. Food can act as a carrier for viruses; however, viruses cannot reproduce in food. Hepatitis A is a virus that can be carried in food when personal hygiene practices are not observed. This virus is not always destroyed when cooking. Talaro and Talaro (1993) explain that the symptoms of Hepatitis A are "flu-like" but can also consist of "loss of appetite, nausea, diarrhea, fever, pain and discomfort in the region of the liver, and darkened urine."

It is not possible to eliminate all microorganisms from food so steps need to be taken to control the outbreak of foodborne illnesses. Talaro and Talaro list several ways in which foodborne illnesses can be prevented: (1.) Fruits and vegetables may be vigorously washed to remove pesticides and microorganisms. (2.) Meat, eggs and milk must be taken from their animal source as aseptically as possible. (3.) Contamination from insects can be prevented by covering food. (4.) When preparing food, utensils need to be cleaned each time a new ingredient is added to prevent cross-contamination. Foods also can be subjected to high temperatures during processing to help eliminate microorganisms.

Foods have a Danger Zone in which bacteria can grow at a rapid rate. This temperature range is about 40-140°F. When holding foods, they need to be held at temperatures above 140°F, and when storing foods, they need to be held at temperatures below 40°F. If temperatures of food are allowed to remain in this Danger Zone, bacteria present will grow and reproduce toxins which can cause foodborne illnesses.

Personal hygiene is important for all personnel who handle food. Personnel should bathe before going to work. Most companies provide uniforms and require personnel to dress at work. This helps to prevent contamination from outside sources. The Educational Foundation of the National Restaurant Association (EFNRA) specifies when hands should be washed. According to EFNRA, hands need to be washed before starting work, after going to the restroom and during work. They should also be washed after handling raw food, touching any part of your body, sneezing or coughing, and smoking. It is best if disposable gloves are used since they can easily be changed, helping to prevent contamination. No jewelry or nail polish should be worn since it can end up in the food. Hair restraints and beard nets are required to prevent hair from falling into the food. Similar instructions are included in the 1997 Food Code, produced by the FDA. The information is available at a very low cost from the FDA, or free on the Internet at: http://vm.cfsan.fda.gov/~dms/fc-toc.html.

All equipment and surfaces need to be cleaned and sanitized on a regular basis. Cleaning refers to the removal of dirt and stains that appear on the surface of equipment and other working surfaces. The EFNRA defines sanitizing as a process that "reduces the number of harmful microorganisms" present on the equipment and surfaces. Equipment and surfaces need to be cleaned and sanitized after each use, after interruptions, or when changing products, and at least every four hours for equipment in constant use.

Hot water, detergent and clean drinkable rinse water can be used for cleaning. Very hot water (170°F) or chemicals can be used for sanitizing. According to Hayes (1985), the different chemical disinfectants are classified into the following groups chlorine-releasing compounds, quaternary ammonium compounds, iodophors and amphoteric compounds.

The EFNRA lists six steps to use when cleaning and sanitizing equipment: (1.) Make sure equipment is turned off. (2.) Unplug electrical equipment. (3.) Unfasten removable parts. (4.) Wash and sanitize each part. (5.) Rinse and sanitize other surfaces with chemical sanitizer, following the manufacturer's directions. (6.) Air dry all parts before putting equipment back together.

Contamination can occur when food is handled often and for long periods of time. If work area and utensils are not properly cleaned, then cross-contamination can occur. The EFNRA indicates that cross-contamination can be prevented by "washing your hands as often as needed, touching food with your bare hands as little as possible, cleaning and sanitizing all utensils that touch food." When using utensils, make sure they are clean and only touch the handle with your bare hand to prevent the food from getting contaminated. When tasting food, make sure the utensils are not put back into the food once it has been placed in your mouth.

References

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Hayes, P.R. *Food Microbiology and Hygiene.* New York: Elsevier Applied Science Publishers. 1985.

Jay, J.M. *Modern Food Microbiology.* 4th ed., New York: Chapman and Hall. 1992.

Mehas, K.Y. and Rodgers, S.L. Food Safety in *Food Science: the Biochemistry of Food and Nutrition.* 3rd ed., New York: Glencoe/McGraw-Hill. 1994. 275-285.

Talaro, K. and Talaro, A., *Foundations in Microbiology.* Iowa: Wm. C. Brown Publishers. 1993.

Serving Safe Food, 2nd ed., Employee Guide. Chicago: The Educational Foundation of the National Restaurant Association, 1993.

Vail, G.E., J.A. Phillips, L.O. Rust, R.M. Griswold, and M.M. Justin. Sanitation in Food Preparation and Service in *Foods.* Boston: Houghton Mifflin Company. 1978. 30-36.

Teacher Note:

Useful food safety and sanitation sites on the Internet:

http://food4kids.missouri.edu

http://vm.cfsan.fda.gov/~dms/fc-toc.html — new food code reference

Learning Activities

1. **Foodborne illnesses and contamination**

   a. Read and discuss chapter 17 in *Food Science: The Biochemistry of Food and Nutrition* by Mehas and Rodgers.

   Discussion Topics:

   Identify the types of microorganisms that cause foodborne illness.

   Compare and contrast the positive and negative effects of these microorganisms in food.

   Relate these microorganisms to foodborne illnesses.

   Describe environmental conditions that encourage growth of microorganisms.

   Explain the symptoms and causative agents of these major foodborne illnesses.

   List the personal hygiene steps required when handling food.

   Identify other resources that are available on foodborne illness.

   Review the major types of hazards that cause foodborne illnesses.

   b. Bring in articles on foodborne illnesses and contamination or write about a foodborne illness that affected you or a family member.

   Discussion Topics:

   What are the consequences of these illnesses?

   How many people were affected?

   How was the food contaminated?

   Do you think hand washing would have prevented this illness?

   What other personal hygiene steps should have been taken to prevent this illness?

   c. Make a video or observe someone preparing food in the kitchen. Identify safe and unsafe food handling practices. Write a critique illustrating safe and unsafe food handling practices.

   Discussion Topics:

   What unsafe practices were observed?

   What are the consequences of these actions? How can they be corrected?

   What safe practices were observed?

   Why are these practices important?

2. **Food handling practices and sanitation applications in food manufacturing/food processing/food preparation**

   a. Invite a local food inspector from the health department to come to your class and explain what they look for when inspecting a food establishment or a food processing plant.

Discussion Topics:

What is the inspector's role?

How are different businesses evaluated?

What does an inspector look for?

Why is this important to the consumer? To the industry?

b. Develop your own safety and sanitation checklist for performing a food safety inspection. Use this checklist to visit a food establishment or a food processing plant. Interview the management about the company's safety and sanitation program.

Interview questions:

What special steps does your company take to make sure safe and sanitary conditions occur?

Have you ever had any complaints from customers who claimed they got sick from eating your food? If so, what actions were taken by your company?

(i.) Share your findings with the class.

Discussion Topics:

Briefly describe your visit.

What were the company's answers to your interview questions?

How do your findings affect the community or your family?

Based on your visit, would you be comfortable being a consumer of their product? Why or why not?

(ii.) Write a letter of thanks to the company for the tour and information.

c. Grow microorganisms in the classroom.

(i.) Use the experiment **Growing One-Celled Organisms: Yeast**. Write a lab report which includes the answers to the questions asked in the experiment.

3. The food you eat

a. Working in groups, examine a brown bag lunch and discuss ways it could have become contaminated.

Discussion Topics:

Predict how the various food items could become contaminated.

What steps should be taken to prevent this contamination?

Analyze the types of microorganisms that might be found in this food.

What type(s) of foodborne illness could you contract from this food?

Describe environmental conditions that could affect whether or not this food becomes contaminated.

b. Your class is working for Swanson's, planning and preparing foods for TV dinners. Divide into groups. Each group will make a dish that can be produced as a TV dinner. One person from each group serves as an observer and uses the food inspection checklist to critique the preparation of the meal.

Discussion Topics:

What unsafe and unsanitary practices were observed during food preparation?

What safe and sanitary practices were observed during food preparation? Would you feel safe eating this meal? Why or why not?

Assess the practical importance of sanitation.

c. Demonstrate how microorganisms can spread infection using the experiment **Microbes Spread Infection**. Write a lab report which includes the answers to the questions asked in the experiment.

Assessment

Paper and Pencil

1. With references, identify the different types of foodborne illnesses, the causes and symptoms. (C6 and C7)
2. Without references, list the different personal hygiene steps to prevent contamination of food. (C10)
3. Create a list of key items for food inspections. (C5, C6, C8, C9, C10, C11)
4. Write a report detailing your safety inspection visit to a food processing plant or food establishment. (C4, C5, C8)
5. Create a table or chart describing different microbial cultures over a period of time. (C5)

Classroom Experiences

1. Critique a video showing safe and unsafe sanitary practices. (C8, C9, C10, C11)
2. Keep a journal which analyzes the articles, from the newspaper, or relate your personal experience, about foodborne illnesses or contamination. (C4, C6, C7, C8, C9, C10)
3. Create a checklist for food inspections. (C5, C6, C8, C9, C10, C11)

Application to Real-life Settings

1. Evaluate a brown bag lunch. Write down ways in which the food can be contaminated. (C1, C4, C5, C7, C8, C9)

2. Write a critique of the safe and unsafe practices performed while preparing a meal by using the checklist created for food inspections described in Classroom Experiences #3 above. (C5, C6, C8, C9, C10, C11)

Laboratory Experiment

NAME_____ DATE_____ CLASS PERIOD_____

INTRODUCTION

All organisms must reproduce themselves in order to survive. Single-celled organisms reproduce asexually. Asexual reproduction means that each individual reproduces without any contact with another organism. Some organisms split in two. This is called fission and occurs when an organism divides equally in half. Some types of fungus reproduce by sporulation. They produce one-celled fragments called spores from which mature organisms can grow. Yeast, which is a form of fungus, reproduces differently from other single-celled fungi. Yeast cells reproduce by budding. A small fragment, called a bud, begins to grow on a parent cell. As the bud grows, the cell wall of the parent begins to close between the parent and the bud, and the bud separates, becoming a new yeast cell. Observe how yeast cells grow and divide in this experiment.

PROCEDURE

Part A Observing Yeast Grow

1. Fill bottoms of two petri dishes ½ full with warm water. Dissolve 1 teaspoon sugar in one. Stir.
2. Sprinkle 1/4 teaspoon yeast in each dish and cover them. Allow the dishes to sit undisturbed for ½ hour in a warm place.
3. After ½ hour observe the petri dishes; record your observations on the data table on page 2.
4. Dispose of the contents of both dishes.

Part B Respiration

1. Fill the soda bottle ½ full with warm water. Add 3 tablespoons sugar and one package of dry yeast. Stir.
2. Cover the bottle top with the balloon. Observe after 15 minutes. Record what has happened to the balloon on page 2.
3. Remove the balloon and light a match. Place the match in the mouth of the bottle. Observe what happens, and record the results on the data table on page 2.

Laboratory Experiment

NAME_____ DATE_____ CLASS PERIOD_____

Part C Reproduction

1. Fill the small jar 1/2 full with warm water.
2. Dissolve 6 teaspoons sugar in the water.
3. Add 1/4 package yeast to the water and sugar solution and stir.
4. Using the dropper, place a drop of this mixture on a microscope slide and cover it with a coverslip.
5. Observe the slide under the microscope at high power.
6. Draw a picture on page 3 of what you observe.
7. Cover the jar and set it in a warm dark place for 48 hours.
8. After 48 hours, open the jar. Note the odor.
9. Prepare a microscope slide as you did in step 4 and observe.
10. Draw a picture on page 3 of your new observation. Compare this to your observations and drawing from 48 hours earlier.

DATA TABLE: Growing Yeast

Procedure	Time before observation	Observation
Yeast in dish with water	½ hour	
Yeast in dish with sugar water	½ hour	
Yeast in bottle with balloon		
Yeast in bottle with match	_____	
Yeast under microscope	initial	
Yeast under microscope	48 hours	

Laboratory Experiment

NAME_____ DATE_____ CLASS PERIOD_____

Drawings based on observations under the microscope

Initial Observation	48 hours later

CLEAN-UP INSTRUCTIONS

(Provided by teacher)

QUESTIONS & CONCLUSIONS

1. What happened in the two petri dishes? What do you think caused any observable differences?
2. What happened to the balloon? The match? Why do you think this happened?
3. Compare the first drop you observed under the microscope with the second drop. How are they different? What process is taking place in the cells in the second drop?
4. Describe the odor that came out after opening the jar.
5. What purpose do you think the sugar and molasses served?
6. How can the results of this experiment be applied in the home? Within the workplace?

Source: Facts on File. *More Science Experiments on File™*. New York, New York: 1991.

For Teacher Use - Growing One-Celled Organisms

TIME: **1-1/2 hours with 20 minutes observation 48 hours later**

SAFETY PRECAUTIONS: **There are no biological hazards involved in this experiment. You may dispose of solid waste by washing it down the drain or dispose of yeast mixture by flushing down the toilet after completion of experiment. It is beneficial to the septic system.**

Explain the following safety precautions to students before proceeding with this lab:

Electrical Safety - Plug and unplug microscope with care; must have dry hands.

Personal and Clothing Safety - Wear an apron to protect clothing.

Fire Safety - Be careful using matches.

Glassware Safety - Handle glassware with care.

Personal Hygiene Safety - Do not taste the yeast mixture.

Garbage Disposal - Discard waste as directed by your teacher; clean work area.

Equipment Use and Safety - Properly and safely use equipment.

Materials and Equipment Needed		
2 petri dishes with covers 16-oz soda bottle small 6- or 8-oz jar with cover	eyedropper balloon 2 packages yeast sugar	sugar water microscope microscope slides cover slips stirring rods

ANSWERS TO QUESTIONS AND CONCLUSIONS

1. In the petri dish containing only water and yeast, most of the yeast sank to the bottom of the dish. In the dish with added sugar, the yeast rose to the top of the dish and formed a bubbling mass of foam.

2. The balloon expanded as it filled with gas from the respiration of the yeast. The match goes out in the presence of the gas which the yeast are respiring. The expanding balloon tells you that there is gas present which was not in the bottle when you began. The fact that the match goes out tells you that the gas is not air or oxygen. The gas is carbon dioxide, which is the waste product that forms as yeast digests sugar. Because yeast produces carbon dioxide, it is used in the manufacture of bread. The yeast digests the sugar and some of the flour used to make bread, and the carbon dioxide that is formed fills the dough with little bubbles. This causes the bread to "rise," and forms the little air pockets which you see when you look at a piece of bread.

3. The first drop you observed under the microscope contained adult yeast cells, which were very much alike. The drop observed several days later contained cells in various stages of reproduction. The cells that have small projections coming off their bodies are the in the process of budding.
4. The odor you smelled upon opening the jar was alcohol. As yeast digests sugar, it produces carbon dioxide and alcohol as waste products. This process, called fermentation, is used to make beer and other alcoholic beverages.
5. The sugar provides food for the yeast.
6. Discuss the conditions which are favorable for producing yeast and the precautions for protecting foods.

Laboratory Experiment

NAME_____ DATE_____ CLASS PERIOD_____

INTRODUCTION

In the late 19th and early 20th centuries scientists attributed disease and decay to small invisible agents called microbes. We now know that there are numerous types of microscopic life-forms which are capable of aiding or harming life. The three basic "microbe" types are bacterium, fungus and virus. (Note: It is still a matter of controversy whether or not viruses are considered alive.) These life-forms are incapable of manufacturing their own food and must feed on other organisms at the cellular level, causing them to rot, mold or become diseased. This lab will examine factors that aid or hinder the spread of bacteria.

PROCEDURE

Part A: Five days before beginning the experiment, take an apple and bruise it by dropping it on the floor lightly. Set this in a warm dark place until you are ready to begin Part B.

Part B

1. Label five plastic bags 1 through 5. Label a sixth bag C for control.
2. Spread newspaper over the top of a table. Place the seven apples in front of you.
3. Place one apple in the bag labeled C. Place a second apple aside without a bag. These are your two controls.
4. Rub the decaying apple from Part A above all over the five remaining apples. Discard the decaying apple when you are finished with it. Wash your hands well with soap and water.
5. Bruise one apple by dropping it on the floor several times. Place this apple in the bag labeled 1.
6. Gently puncture another apple several times with the paring knife. Place this apple in bag 2.
7. Wash a third apple thoroughly with soap and water. Dry it well and place it in bag 3.
8. Clean another apple with isopropyl alcohol, rinse it with water. Dry this apple thoroughly and place in bag 4.
9. Do not do anything to the last apple. Place it in bag 5. Wash your hands. Examine the six apples in their bags and the seventh apple not placed in a bag. Notice any bruises, discolored places or breaks in the skin present on any of the apples. Record these on the data table under **Initial Observations**.
10. Place all seven apples in a warm dark place; leave them there for one week.
11. After one week examine all the apples. Compare the two control apples. Compare apples 1-5 with the controls. Record observations in data table.

Laboratory Experiment

NAME_____ DATE _____ CLASS PERIOD_____

DATA: Microbes and Infection

Apple Condition	Treatment	Initial Observations	Conditions after a Week
C (no bag)			
C (bag)			
1			
2			
3			
4			
5			

CLEAN-UP INSTRUCTIONS

(provided by your teacher)

QUESTIONS & CONCLUSIONS

1. What was the purpose of the control apples? Why were two controls used?
2. What happened to each apple? Why did the differences you observed occur?
3. What differences did you observe on the apple washed with soap and water? The apple washed with alcohol and water? Explain.
4. What do your observations suggest about the reason it is important to wash your hands in steps 4 and 9 of the procedure?

Source: Facts on File. *More Science Experiments on File™*. New York, New York: 1991.

For Teacher Use - Microbes Spread Infection

TIME: 5 days before preparation; 45 minutes preparation; observation 1 week later.

SAFETY PRECAUTIONS: Explain the following safety precautions to students before proceeding with this lab.

Chemical Safety - Do not eat food samples.
Personal and Clothing Safety - Wear an apron to protect clothing.
Hand Safety and Protection - Be careful handling the knife; always point the blade away from you.
Personal Hygiene and Safety - Wash your hands well after handling the decayed fruit.
Waste Disposal - Clean work area; dispose of waste properly.

Materials and Equipment Needed		
1 decaying apple (bruise an apple and set it out 5 days before beginning) 7 fresh apples (all approximately the same size)	6 sandwich-size plastic zip-lock bags isopropyl alcohol soap paring knife masking tape or stick-on-labels	water marking pen paper newspaper

ANSWERS TO QUESTIONS AND CONCLUSIONS

1. The control apples allow you to compare the "infected" apples to an apple in a "normal" state. The reason for having two controls is that placing an apple in a plastic bag might have an affect on whether it rots or not. So, this becomes an experimental variable and must be isolated.
2. Results may vary a bit depending on factors that you have not controlled in the experiment, such as, the age and initial condition of the apples, how thoroughly you washed the third apple, and how severely you cut and bruised the apples. Control 1 - No change; Control 2 - No change; #1 - Severe rotting; #2 - Rotting at cuts; #3 - Slight discoloration; #4 - No change and #5 - Some rotting probable. Since the control apples remain undamaged and have had no contact with the rotting apple, it will take a longer period of time for them to begin to rot. The skin of the apple acts as a protective cover and makes it harder for bacteria and fungi to attack the apple. The bruised and cut apples decay because the protective barrier has been damaged or broken, allowing the bacteria into the apple itself where they can begin to digest it and cause decay. If your findings vary from the probable findings listed above, refer back to your initial observations. For instance, if you observed bruises on any of the apples these would tend to hasten decay.
3. Washing the apples removes the bacteria from the surface of the apple so that decay cannot start. Using alcohol kills the bacteria. This is why alcohol is used on your skin before the doctor gives you an injection.

4. Washing your hands removes any bacteria on them from the rotting apple. The bacteria could cause an infection if you cut or scraped your hand while the bacteria was present, or if you ingested any of the bacteria.

Source: Facts on File. *More Science Experiments on File™*. New York, New York: 1991.

Module 5 Overview

Practical Problem:

What is HACCP (Hazard Analysis Critical Control Points), and what is its significance to the food industry?

Competency:

C2 Identify principles of HACCP (assess hazards, identify critical control points, set up control procedures, monitor critical control points, take corrective actions, develop a record keeping system, verify that the system is working).

Supporting Concepts:

1. HACCP
2. Flow diagrams
3. Principles of HACCP

Teacher Background Information

Rationale

The Pillsbury Corporation developed the HACCP program for NASA (the National Aeronautics and Space Administration). It was designed to make sure the astronauts received safe food. This concept has slowly been adopted by the food industry for various products (Jay, 1992). HACCP is designed to show where all possible microbial contamination could occur which would cause foods to be considered unsafe for human consumption. The U.S. Food and Drug Administration (FDA) has started to require HACCP plans for the seafood industry, while the US Department of Agriculture (USDA) requires all meat and poultry processing facilities to use HACCP plans. Eventually, all of the food industries will be required to have a HACCP plan on file.

Background

HACCP stands for Hazard Analysis Critical Control Points and is used in the food industry to identify locations where microbial contamination could occur that would render food unsafe. It diagrams the complete process required for the food item being manufactured and possible locations or sources that could allow microorganisms to enter the food.

The first step for creating a HACCP program is to diagram the complete process from start to finish. Flow diagrams are used for this purpose. Start with the raw ingredients, how the foods are processed and stored. Then each processing step is listed, including the packaging and storage conditions. (Refer to **Process Flow Diagram for a Multi-grain Rice Cake** and **Reference for Critical Control Points for Multi-grain Rice Cake** student handouts.)

Hazards associated with the raw ingredients, processing and storage are assessed. Jay (1992) defines a "hazard" as any biological, chemical or physical property that can cause an unacceptable consumer health risk. Once hazards have been determined, then the risks linked with that hazard are classified as either high, medium or low.

To control the identified hazards, critical control points (CCPs) are designated. CCPs are locations in the process which could create or allow a hazard to occur. Other areas in the process may appear to be CCPs; however, the hazard is actually dealt with at other locations.

Critical limits are required for each CCP to make sure the hazard has been controlled. Critical limits are tolerances set by the company, the industry or the government. Critical limits are commonly set for the amount of time required to reduce microbial activity, the temperature required, moisture level, pH, preservatives, and viscosity levels.

Once CCPs and critical limits have been established, a system to monitor them should be implemented. It is best if the monitoring procedure is a continuous process but this is not always possible. What is important is that CCPs are controlled and the critical limits are maintained. Documentation should be kept on the monitoring process for auditing purposes. Monitoring CCPs can be as simple as recording the conditions of the process to sample testing for the specific condition.

Establish corrective actions when control of a CCP no longer exists. These are written procedures to obtain control of the CCP. If a product is produced while the CCP is out of control, appropriate steps must be included in these procedures for disposal of the product, whether it is discarded or reworked.

Periodic checks verify the HACCP program works. These can be "methods, procedures, or tests" that are not normally performed when monitoring CCPs.

Document HACCP plans and store them on file at the processing facility. All records pertaining to the ingredients, processing, packaging, storage and distribution are included in this file. Make the file available to any inspectors who visit the plant.

References

Hubbard, M.R. Sampling in *Statistical Quality Control for the Food Industry*. 2nd Edition, New York: Chapman and Hall. 1996. 136-145.

Jay, J.M. Microbiological Safety of Foods in *Modern Food Microbiology*. 4th Edition, New York: Chapman and Hall. 1992. 434-440.

Macrae, R., R.K. Robinson, and M.J. Sadler, eds. Hazard Analysis Critical Control Point in *Encyclopaedia of Food Science, Food Technology and Nutrition*. New York: Academic Press. 1993. 2289-2293.

Learning Activities

1. HACCP

Using the **Seven Principles of HACCP** Instructor Sheet, discuss how these principles are used to maintain food safety in a processing plant.

Discussion Topics:

List the hazards associated with raw ingredients, processing and storage.

What constitutes a critical control point (CCP)?

What are critical limits?

How can a CCP be monitored?

What types of documentation are required for a HACCP program?

Describe ways in which you can verify a HACCP program works.

2. Flow Diagrams

a. Review the **Reference for Critical Control Points for Multi-grain Rice Cake Example** Instructor Sheet. Discuss **Multi-grain Rice Cake Process Flow Diagram** Instructor Sheet.

Discussion Topics:

List the hazards associated with the raw ingredients, processing and storage.

What are the critical control points (CCPs)?

What are the critical limits for the CCPs?

How can the CCPs be monitored?

Identify the documentation required for this HACCP program.

Explain the ways in which this HACCP program can be verified.

b. Create a flow diagram for a food product that has at least three ingredients. (*e.g.,* a hamburger, cheese sandwich or pot roast)

Discussion Topics:

What are the hazards associated with the raw ingredients, processing and storage?

What are the critical control points (CCPs)?

What are the critical limits for the CCPs?

How can the CCPs be monitored?

Identify the documentation required for this HACCP program.

Explain the ways in which this HACCP program can be verified.

c. Complete **Jumbled Processes for Dry Corn Bread Mix** Activity Sheet and draw a flow diagram.

Discussion Topics:

What is the correct order for these processes?

Which process is used twice?

3. Principles of HACCP

a. Bring an article related to HACCP to class. Discuss its significance for the food industry. Write a summary about the article and how it is related to HACCP.

Discussion Topics:

How does the article pertain to HACCP?

How has HACCP helped the food industry or the specific company in the article?

What effects has HACCP had on the food industry or the specific company in the article?

Why is HACCP important to the consumer?

Assessment

Paper and Pencil

1. Draw a flow diagram of a food process.
2. Using the **Jumbled Processes for Dry Corn Bread Mix activity sheet,** place the processes in the correct order. Then, create a flow diagram of these processes.

Classroom Experiences

1. Summarize your article from Learning Activity #3 and its relationship to HACCP. Present your findings to the class.

Application to Real-life Settings

1. Make arrangements to watch someone prepare a family dinner. Note each step in the process, starting with obtaining the food at the grocery store and finish when the food is on the table. Be sure to observe when foods change temperature. Note how long they stay in the Danger Zone (40°- 140°F). Prepare a HACCP chart for the food that you think is most likely to cause disease if it is not prepared correctly.

   Discussion Topics

   Identify at least two critical control points.

   How could you verify your HACCP plan?

   Could you keep records to prove your food was prepared safely?

Teacher Note:

When discussing at least two critical control points, time and temperature should always be mentioned. Cross-contamination is also a common issue. HACCP plans can be verified when no one gets sick or by sending samples to a lab.

Instructor Sheet

Seven Principles of HACCP

Food Processing Safety Procedures

1. Assess the hazards and risks associated with the raw ingredients, processing and storage.

2. Establish the critical control points (CCP) at locations where one of the identified hazards could occur.

3. Determine the critical limits for each identified CCPs.

4. Outline procedures required to monitor the CCPs.

5. Determine corrective actions.

6. Create procedures to verify the HACCP program works.

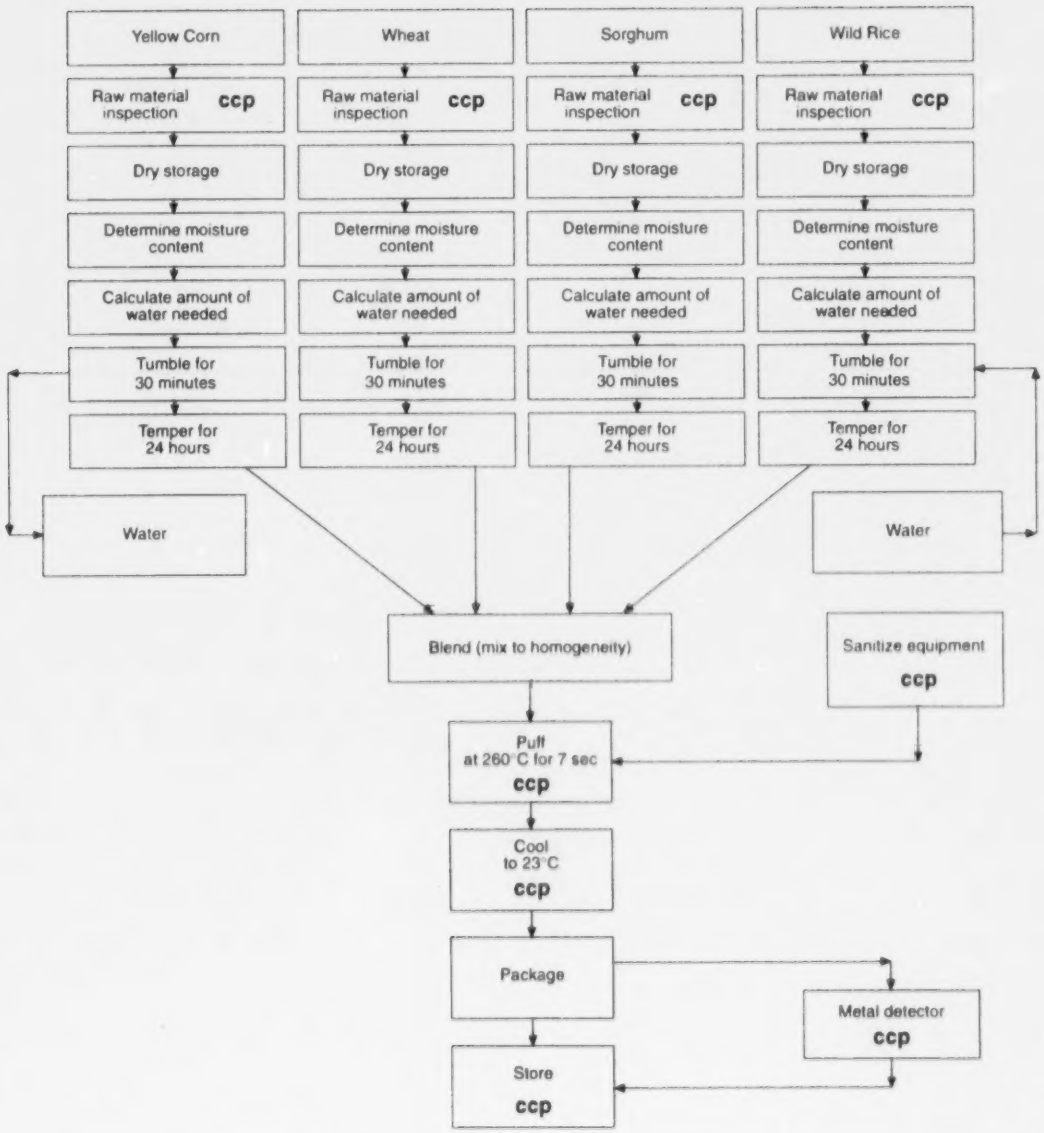
7. Document the HACCP program.

Source: Jay, J.M. 1992. Microbiological Safety of Foods in *Modern Food Microbiology*. 4th Edition, Chapman and Hall, New York. p. 436.

Instructor Sheet

Multi-grain Rice Cake

PROCESS FLOW DIAGRAM



Instructor Sheet

Reference for Critical Control Points

Multi-grain Rice Cake Example

⊡ CCP Raw Material Inspection

Raw material must be inspected for presence of aflatoxin, *B. stearothermophilus*, and *B. cereus* to ensure that the contamination is not above the allowable levels. The inspection will be performed by statistical sampling using a 1% confidence level.

⊡ CCP Sanitize Equipment

Ensuring sanitary and hygiene practices while handling the tools and equipment will lower the risk of contamination of the product with thermophilic organisms from the outside environment.

⊡ CCP Puff at 260°C for 7 seconds

Heating of the mixture of grains is likely to activate the spores of *B. stearothermophilus* and *B. cereus*. Therefore, the temperature must reach 260°C, which is sufficient to destroy these organisms.

⊡ CCP Cool to 23°C

This step involves exposure of the finished product to the environment. Necessary precautions need to be made in order to protect the product from cross-contamination.

⊡ CCP Metal Detector

A metal detector system must be incorporated into the packaging line to ensure metal objects are not in the product. The metal detector should be checked every two hours to ensure it is operating properly.

⊡ CCP Store

The finished packaged product must be stored in dry cool conditions. Exposure to moisture can cause the cakes to become stale and can contribute to mold growth.

Activity Sheet

JUMBLED PROCESS FOR DRY CORN BREAD MIX

NAME_____ DATE_____

List the following processes in the correct order. You will need to use one of the processes more than once.

Process	Order
Sift	1. _____
Package	2. _____
Store	3. _____
Blend	4. _____
Inspect Raw Ingredients	5. _____
Check Metal Detector	6. _____
Ship	7. _____
Weigh	8. _____
	9. _____

Create a flow diagram of the procedures in the box below. (Use back side of handout if needed.)

For Teacher Use - Answers to Learning Activities

Answer to Learning Activity 1. HACCP

a. *List the hazards associated with raw ingredients, processing and storage.*

Storage conditions (time and temperature)

Microbial limits for the type of food

Sanitation of equipment and utensils

Personal hygiene

Processing conditions (time and temperature)

Metal or foreign objects entering the product

What constitutes a critical control point (CCP)?

Some point in the process where a hazard can be controlled.

Explain critical limits.

Tolerances for specific conditions such as refrigeration temperatures, processing temperatures and times, and tolerable microbial counts.

How can a CCP be monitored?

By scheduling tests or making observations of the CCP and recording these results in charts or tables. Examples would be time, pH, temperature, water activity, microbial counts and calibration of equipment.

What types of documentation are required for a HACCP program?

Manual covering the procedures of the HACCP plan

Monitoring records

Product description including product codes, dates and times

Calibration records

Corrective action plans

Describe ways to verify a HACCP program works.

Inspections of the plans, records and methods

Random sampling checks

Sources:

Hubbard, M.R. Sampling in *Statistical Quality Control for the Food Industry.* 2nd ed., New York: Chapman and Hall.1996. 136-145.

Jay, J.M. Microbiological Safety of Foods in *Modern Food Microbiology.* 4th ed., New York: Chapman and Hall.1992. 434-440.

Answers to Learning Activity 2. Flow Diagrams

a. *List the hazards associated with the raw ingredients, processing and storage of the Multi-grain Rice Cake.*

Microorganisms present in the grain

Unsanitary equipment

Microorganisms present during processing

Storage during processing
Metal fragments or nuts and bolts from the equipment
Storage of finished product

What are the critical control points (CCPs)?

Inspecting the grains when they are received
Sanitizing the equipment
Puffing times and temperatures required to destroy microorganisms
Storage conditions of cakes during the cooling process
Metal detector
Storage conditions of finished product

What are the critical limits at the CCPs?

Statistical sampling at the 1% level during inspection of the grains
Sanitizing equipment has no critical control limits
Puffing at 260 °C for 7 seconds
Cooling cakes to 23 °C
Metal detector checked every two hours
Storage in a cool, dry location

How can the CCPs be monitored?

Microbial counts of raw grains and after processing
Recording the time and temperatures during processing and storage
Metal detector records

Identify the documentation required for this HACCP program.

Manual covering the procedures of this HACCP plan
Monitoring records
Product description including product codes, dates and times.
Metal detector records
Corrective action plans

Explain the ways in which this HACCP program can be verified.

Inspections of the plans, records and methods
Random sampling checks of the cakes

b. *Answers will vary based on food product selected.*

c. *Jumbled Processes for Dry Corn Bread Mix*

1. Raw Ingredients
2. Storage
3. Sift
4. Blend
5. Package
6. Weigh
7. Metal Detector
8. Storage
9. Shipping

Answers to Learning Activity 3. Principles of HACCP will vary among students.

Module 6 Overview

Practical Problem:

What is the importance of Material Safety Data Sheets (MSDS) in the food industry?

Competency:

C12 Identify location of, and information on, MSDS.

Supporting Concepts:

1. Material Safety Data Sheets

Teacher Background Information

Rationale

OSHA (Occupational Safety and Health Administration) requires all facilities to maintain an MSDS for each hazardous chemical used. MSDS provide information about how to handle the chemicals, the necessary steps to take for disposal of them, and any emergency or first-aid responses needed to prevent accidents.

Background

Material Safety Data Sheets (MSDS) are provided by chemical companies to inform others about proper handling conditions and any hazards associated with hazardous chemicals. This includes chemicals purchased by schools for instructional purposes.

OSHA specifies seven different sections that need to be covered on an MSDS (University of Iowa, 1997). These are chemical identity; physical and chemical characteristics; fire and explosion hazard data; reactivity data; health hazards; precautions for safe handling and use; and control measures. Information that is required in each section is listed in Appendix II, Material Safety Data Sheets (MSDS) Example, Explanation and Glossary by the University of Iowa. Each chemical company has its own format, however, the information listed is similar. (Sample Material Safety Data Sheet at the end of this module.)

MSDS are provided by the chemical company when chemicals are purchased. If the MSDS do not accompany the chemicals, the company should be notified. The MSDS should be stored in a binder or folder and maintained on file for everyone's use. They should be located close to the chemicals for easy access, but are sometimes centrally located in a company.

Several different web sites are available describing MSDS terminology and how to read MSDS. Some of these are: http://www.bris.ac.uk/Depts/Chemistry/admin/safety/msds.htm, http://www.library.wisc.edu/guides/Biology/msds.html, http://www.chemsafe.com/msds_terms.html, and http://www.uiowa.edu/~vpr/research/hpo/chem/aii.htm.

References

Toreki, R. Where to find MSDS on the Internet. 1997.
http://www.chem.uky.edu/resources/ msds.html.

Jourdan, D. Biology: Chemical Safety Information/MSDS. 1995.
http://www.library.wisc.edu/guides/ Biology/msds.html.

Chemical Safety Corporation. MSDS Terminology. 1995.
http://www.chemsafe.com/msds_terms.html.

University of Iowa. Appendix II, Material Safety Data Sheet (MSDS) Example, Explanation and Glossary. 1997.

http://www.uiowa.edu/~vpr/research/hpo/chem/all.htm.

Learning Activities

1. MSDS

a. Using the sample **Material Safety Data Sheet**, discuss the different sections and the information available.

Discussion Topics:

What are the sections on the MSDS?

Why is the information in each section important?

Where are MSDS located in a company?

Who should have MSDS?

b. Look up MSDS on the Internet. Find an MSDS, print it and keep a copy for reference.

Discussion Topics:

What information is available on the MSDS?

How are MSDS used?

Where are MSDS found?

What is their importance to food companies and consumers?

c. Work in cooperative groups of five, using the Web site **http://www.chem.uky.edu/resources/msds.html**. Look up at least three of the organizations under the five different headings: General sites, Government and nonprofit sites, Chemical manufactures and suppliers, Agricultural-pesticides and herbicides, and Miscellaneous. Look up the same chemical in each organization and print it.

Discussion Topics:

Which organizations did you look up?

Do the MSDS have the same format?

Is the information listed on the MSDS similar?

How are these MSDS used?

What is their importance to food companies and consumers?

d. Choose a chemical from the lab. Using the Internet, look up the company who manufactures that chemical to see if an MSDS for that chemical is available.

Discussion Topics:

Which company produces this chemical?

What information is available on the MSDS?

How are MSDS used?

Where are MSDS found?

Do you think a food processing company would use this chemical? Why or Why not?

e. Select a chemical that is used either to make a food product or one that could contaminate a food product (e.g., used during sanitation of the equipment). Using any resource available, locate an MSDS for this chemical.

Discussion Topics:

What information is available on the MSDS?

How are MSDS used?

Where are MSDS found?

What is the importance of this MSDS to food companies and consumers?

Assessment

Paper and Pencil

1. List the main sections located on an MSDS.

Classroom Experiences

1. Print an MSDS from the Internet. Compare your printout with those from other students.
2. After visiting the lab, locate an MSDS for a chemical.

Application to Real-life Settings

1. Locate an MSDS for a chemical that is associated with food processing.

Material Safety Data Sheet

Any Chemical Company · 500 Anywhere · USA 00000-0000

"The information herein is given in good faith, but no warranty, expressed or implied, is made"

Emergency Telephone No.: 1-800-000-0000

Date Prepared: April, 1996

SECTION I

Chemical Name and Synonyms: Providone Iodine Solution USP, PVP-I

Trade Name: Iodine Solution (10% Providone Iodine = 1% Available Iodine)

Chemical Family: Polymer, complex of Polyvinylpyrrolidone with iodine

Formula: $(C_6H_9NO)_n \times I$

CAS Registry No.: 0000.00

SECTION II: INGREDIENTS

Name	Percent (%)	TLV	Toxicological Data
Providone Iodine USP	10.00	-	Mouse, Oral LD_{50}>8100mg/kg Rat, IV LD_{50}>540mg/kg
Glycerin	1.25		
Igepal	.30		
Purified Water	88.45		

No component is listed by NTP or IARC Not Established as having Carcinogenic Potential

SECTION III: PHYSICAL DATA

Specific Gravity: (25°C) 1.025 **pH:** <6.0

Appearance & Odor: Reddish brown, clear liquid, faint odor

SECTION IV: FIRE AND EXPLOSION HAZARD DATA

Flashing Point (method used): Not flammable **Flammable Limits:** None

LEL: n/a **UEL:** n/a

Extinguishing Media: n/a

Special Fire Fighting Procedures: n/a **Unusual Fire & Explosion Hazards:** None

SECTION V: HEALTH HAZARD DATA

Threshold Limit Value: None established by OSHA or ACGIH

Effect of Overexposure: This product is generally recognized as safe when used as a logical antimicrobial agent. Prolonged exposure to wet solution may cause local irritation to the skin. Elevated concentrations of iodide in the serum may occur if excessive amounts of iodine are absorbed through broken skin, burns, or deep wounds. Iodine may also be absorbed through the lungs and from the gastrointestinal tract. High concentrations of iodide in the serum may produce alterations in thyroid, renal disturbances, acidosis and electrolyte disturbances.

Emergency and First Aide Procedures:

For Eyes: Immediately wash with running water for 5 minutes. Get medical attention if irritation persists.

For Skin: Avoid prolonged contact with excess wet solution. If irritation develops, get medical attention.

For Ingestion: If swallowed, DO NOT INDUCE VOMITING. Drink several glasses of water or milk. Obtain immediate medical attention.

For Inhalation: If fumes cause respiratory discomfort, move to fresh air. Get medical attention if respiratory discomfort persists.

SECTION VI: REACTIVITY DATA

Stability: Stable **Storage:** Store at room temperature.

Incompatibility: Not stable toward reducing agents or strong alkalies.

Hazardous Decomposition Products: None

Hazardous Polymerization: Will not occur

Conditions to Avoid: None **Corrosive to Metal:** Yes

Type: Iron, can discolor gold or silver **Oxidizer:** Yes

SECTION VII: ENVIRONMENTAL DATA

Steps to be Taken in Case Material is Released or Spilled: Spills should be cleaned up as soon as possible, wash affected area with dilute ammonia or dilute sodium thiosulfate solution and copious quantities of water.

Waste Disposal Method: Do not discharge more than minute quantities into waterways or sewer systems. Neutralize with sodium thiosulfate prior to disposal.

Hazardous Substance Under "Superfund": No **Hazardous Waste, 40 CFR 261:** No

Hazardous Waste Number: n/a

Container Disposal: In a similar manner as other plastic bottles.

SECTION VIII: SPECIAL PROTECTION

Respiratory Protection (Specify type): n/a **Protective Gloves:** n/a

Ventilation: Local Exhaust: n/a **Special:** n/a

Mechanical (General): n/a **Other:** n/a

Eye Protection: n/a **Other Protection Equipment:** n/a

SECTION IX: SPECIAL PRECAUTIONS

Precautions to be taken in Handling and Storage: n/a **Other Precautions:** n/a

National Fire Protection Association (NFPA)

Rating Degrees of Hazard:

BEST COPY AVAILABLE

Module 7 Overview

Practical Problem:

What happens to vitamins and minerals during food processing?

Competency:

E19 Discuss the effects of food processing on vitamin and mineral levels in foods.

Supporting Concepts:

1. Vitamins and Minerals

Teacher Background Information

Rationale

Preliminary treatments and food processing affect the nutritional content of food. It is important to determine how vitamins and minerals are lost in order to process foods in a way in which the least amount of nutrient loss occurs.

Background

Vitamins and minerals are lost or destroyed during processing. They are lost due to leaching and are destroyed by oxygen, light, heat, and pH. Nutrients can leach out of the food into processing liquids that are later discarded. Steps are taken to reduce the amount of vitamins and minerals lost while processing food, but it is not possible to prevent these losses completely.

Thermal processing consists of blanching, pasteurization and sterilization. The high temperatures food is subjected to during these processes can destroy vitamins such as vitamin A, vitamin C, biotin, folate, pantothenic acid, vitamin B6, riboflavin, thiamin, vitamin E and vitamin D.

Blanching is a process which subjects fruits and vegetables to high temperatures for a short period of time in order to inactivate enzymes. If enzymes are not inactivated, the food continues to deteriorate which limits its shelf-life. Fruits and vegetables are passed through either steam or hot water during blanching which allows water soluble vitamins and minerals to leach out.

When foods are concentrated, their nutrient content remains the same. The process requires specific membranes to remove water, using the principles of osmosis. Concentrating the product can reduce its cost since it can be stored in a smaller container, requires less storage space and more products can be transported at one time.

Evaporation and dehydration are processes that reduce the moisture content of the food. Both of these methods require heat in order to remove water from the product. The same vitamins that are lost during thermal processing can also be lost from dehydration and evaporation; however, usually fewer vitamins are lost from these two processes than from thermal processing.

Fellows states that when food is frozen, "water soluble vitamins are lost at sub-freezing temperatures." Freeze drying also destroys water soluble vitamins since the food is frozen first and then dried; however, during the drying process, the nutrient loss is small.

Vitamins can be destroyed from chemical reactions that continue in food even after the food has been harvested or processed. Exposure to air oxidizes vitamins such as vitamin A, vitamin C, vitamin B12, folate, thiamin, vitamin E, and vitamin D, inactivating them. Ultraviolet light destroys vitamin A, vitamin C, vitamin B12, vitamin K, folate, vitamin B6, riboflavin, vitamin E and vitamin D .

The pH of the food also affects the activity of vitamins. Folate is unstable at all pH conditions. Vitamin K, and pantothenic acid are only stable at neutral pH. Vitamin C and thiamin are only stable in acidic environments. Vitamin A, is unstable in acidic environments; whereas, riboflavin, and vitamin D are unstable in alkaline environments.

Minerals are not disabled by thermal processing, ultraviolet light, oxidation, or strong acids and bases. Mineral loses are due to "leaching or physical separation". Different methods of processing can cause physical separation such as milling which removes minerals contained in the bran layer or the germ of the grain and cheese manufacturing which loses calcium under acidic conditions.

References

Fellows, P.J. *Food Processing Technology*, New York: Ellis Horwood, Ltd., 1988.

Fennema, O.R. Vitamins in *Food Chemistry* (J.F. Gregory III), New York: Mercel Dekker, 1996. 539-545.

Fennema, O.R. Minerals in *Food Chemistry* (D.D. Miller), New York: Mercel Dekker, 1996. 639-640.

Harris, R.S. and Karmas, E. General Discussion on the Stability of Nutrients in *Nutritional Evaluation of Food Processing*. Connecticut: The AVI Publishing Company, Inc., 1975. 1.

Learning Activities

1. Vitamins and Minerals

a. List the ways in which vitamins and minerals are affected by food processing.

Discussion Topics:

Explain the effects different processing methods can have on vitamins?

Which vitamins and minerals are heat stable?

Which vitamins and minerals are lost due to chemical reactions?

How are minerals lost during food processing?

b. Perform the lab **Titration of Vitamin C** on p. 172 of *Food Science: The Biochemistry of Food and Nutrition* by Mehas and Rodgers. Try a variation in which the juices are exposed to ultraviolet light or sunlight for one week before being titrated.

Discussion Topics:

Was there a difference in the amount of vitamin C present in each juice sample? Why?

What happened to the vitamin C?

c. Complete the lab **Calcium in Milk** on p. 174 in *Food Science: The Biochemistry of Food and Nutrition* by Mehas and Rodgers.

d. Execute the lab **Vitamin Solubility**.

e. Perform the lab **Iron Content of Cereals**.

Assessment

Paper and Pencil

1. Write lab reports for each Laboratory Experiment in Learning Activity 1.

Classroom Experiences

1. Discuss the questions provided with each lab.

Application to Real-life Settings

1. Recall the functions of calcium, iron, and vitamins (the ones chosen for the **Vitamin Solubility** lab). Distinguish ways these nutrients are preserved in food processing.

Laboratory Experiment

NAME_____ DATE_____ CLASS PERIOD_____

INTRODUCTION

Vitamins are organic molecules which are necessary for your body to carry out its metabolic processes. Vitamins can be divided into two major categories based on their chemical structure. They are either water soluble or fat soluble. Water soluble vitamins usually contain oxygen, nitrogen, or sulfur at numerous sites, making the polar molecules which will dissolve in water. Fat soluble vitamins are almost exclusively made of carbon and hydrogen, and are therefore insoluble in water.

PROCEDURE

1. Obtain samples of the different single vitamin supplements to be tested.
2. Set up two test tubes for each vitamin you will be testing.
3. Pour 10 mL of water in half of the test tubes.
4. Pour an equal amount of vegetable oil in the remaining test tubes.
5. Label your test tubes so that you will know which vitamin and which solvent each contains.
6. Using a mortar and pestle or rolling pin, crush a vitamin tablet. Place a small portion of the crushed tablet in the appropriate test tube of water, and stir with your stirring rod. Record your observations (i.e., soluble, partially soluble, insoluble).
7. Repeat using vegetable oil as a solvent. Record your observations.
8. Repeat Steps 6 and 7 for all vitamins in tablet form.
9. For vitamins enclosed in a capsule, pierce the capsule with a toothpick. Add 2-3 drops of the liquid vitamin to a test tube containing water and 2-3 drops to a test tube containing the oil. Record your observations.

Laboratory Experiment

NAME _____ DATE _____ CLASS PERIOD _____

DATA TABLE: Vitamin Solubility

Vitamin	In Water	In Oil	Conclusion

CLEAN-UP INSTRUCTIONS

(Provided by the teacher)

QUESTIONS & CONCLUSIONS

1. Which of the vitamins you tested were water soluble?
2. Which of the vitamins you tested were fat soluble?
3. Name one food source for each of the vitamins you tested.

For Teacher Use - Vitamin Solubility Experiment

TIME: 1 hour

SAFETY PRECAUTIONS: Explain the following safety precautions to students before proceeding with this lab.

Personal and Clothing Safety - Wear an apron to protect clothing.

Glassware Safety - Use caution with glassware; clean glassware prior to and at completion of experiment.

Equipment Use and Safety - Properly and safely use equipment.

Materials and Equipment Needed		
vitamin samples (pills or capsules) test tubes test tube rack	mortar and pestle or rolling pin stirring rod toothpicks	water vegetable oil

Which cooking methods would preserve vitamins in food?

Water soluble vitamins dissolve in water inwhich cut vegetables are washed or boiled. To avoid loss of water soluble vitamins, wash vegetables briefly, do not soak vegetables in water and cut vegetables after boiling. Vitamin loss can be avoided by microwaving vegetables or steaming vegetables over water.

How does the method of preparation affect the nutritional value of food?

Destruction of vitamins can be minimized by avoiding high temperatures and long cooking times.

ANSWERS TO QUESTIONS AND CONCLUSIONS

1. All B vitamins, Vitamin C
2. A, D, E, K
3. Answers will vary

Teacher Note: Excellent resource - Hamilton, Eva May Nunnelley, Eleanor Noss Whitney and Frances Sienkiewicz Sizer. *Nutrition: Concepts and Controversies,* 5th Ed., St. Paul: West Publishing Co. 1991.

Source: *Food Science Experiment and Activity Guide.* ***Raleigh, NC:*** North Carolina Department of Public Instruction, 1994.

Laboratory Experiment

IRON CONTENT OF CEREALS

NAME_____ DATE_____ CLASS PERIOD_____

INTRODUCTION

Most breakfast cereals contain added iron to help consumers meet their minimum Recommended Daily Allowance (RDA) for this essential nutrient. Determine the amount of iron per serving of cereal during this experiment.

PROCEDURE

1. Find the mass of a magnetic stirring bar.
2. Measure one cup of a breakfast cereal.
3. Using a mortar and pestle, crush the cereal. (The crushing may also be done in a plastic bag.)
4. Pour the crushed cereal into a 400 mL beaker. Add 200 mL of water.
5. Add the magnetic stirrer to the cereal and place on a magnetic stirrer.
6. Stir the mixture for about 15 minutes.
7. Carefully remove the stirring bar and place on a paper towel to dry.
8. Observe the appearance of the stirring bar.
9. Find the mass of the stirring bar with the iron that has been attracted to it.
10. The same procedure may be used with instant hot cereals without the addition of water.

DATA TABLE: Iron Content of Cereal

Type of Cereal	Mass of Stirring Bar plus Iron (Fe)	Mass of Stirring Bar	Mass of Iron

CLEAN-UP INSTRUCTIONS

(Provided by the teacher)

QUESTIONS & CONCLUSIONS

1. Compare the class results for the amount of iron per 1-cup serving.
   a. Which cereal has the most iron added?
   b. Which cereal has the least added iron?
2. Why is iron added to breakfast cereal?

For Teacher Use - Iron Content of Cereals Experiment

TIME: 1 Hour

SAFETY PRECAUTIONS: **Explain the following safety precautions to students before proceeding with this lab.**

Chemical Safety - Do not taste any of the substances used in this procedure.
Glassware Safety - Handle glassware with care.
Equipment Use and Safety - Properly and safely use equipment.

Materials and Equipment Needed		
assorted breakfast cereals (include infant iron-fortified)	mortar and pestle beaker	magnetic stirrer magnetic stirring bar

ANSWERS

1. Answers will vary.
2. To supplement daily iron intake; to assist in meeting daily iron requirements.

Teacher Note: A sensitive balance is required to observe a noticable difference in the mass of the stirring bar.

Source: *Food Science Experiment and Activity Guide.* ***Raleigh, NC:*** North Carolina Department of Public Instruction, 1994.

Module 8 Overview

Practical Problem:

How does a solution's concentration affect its physical properties?

Competency:

F5 Analyze the effect of concentration on physical properties of a solution.

Supporting Concepts:

1. Effects of concentration

Teacher Background Information

Rationale

Foods are concentrated so they can be stored in smaller containers, require less storage space and allow more product to be transported at a time. The physical properties of a solution affect the processing conditions required for that food product. By knowing how these physical properties change, proper processing conditions can be used when manufacturing foods.

Background

When a solution becomes concentrated, its physical properties are affected. The physical properties of a solution consist of freezing point, boiling point and vapor pressure. The more concentrated a solution becomes the higher its boiling point, whereas there is a decrease in the vapor pressure and the freezing point. This demonstrates the relationship between the temperature and the vapor pressure and deals with the tendency of the solvent to be able to change from a liquid to a gas or a liquid to a solid. In a concentrated solution, there are fewer solvent molecules and the more concentrated the solution becomes causing a decrease in the vapor pressure. The more concentrated the solution becomes, the less chance the solvent molecules have to change states (i.e., gas or solid). This causes an increase in the boiling point and a decrease in the freezing point of the solution.

References

Bodner, G.M. and Pardue, H.L. Liquids and Solutions in *Chemistry an Experimental Science*. New York: John Wiley and Sons, 1989. 532-535.

Sienko, M.J. and Plane, R.A. Solutions in *Chemistry Principles and Applications*. New York: McGraw-Hill Book Company, 1979. 231-236.

Learning Activities

1. Effects of Concentration

a. List the different properties of a solution and give an example of how each one is affected by the change in concentration of a solution.

Discussion Topics:

What are the different properties of a solution?

How does increasing the concentration affect these properties?

How does decreasing the concentration affect these properties?

Explain how temperature affects the concentration of a solution?

What other properties of the solution are affected by changing the temperature?

b. Perform the lab **Boiling Points of Sugar and Salt Solutions** on p. 221 in *Food Science: The Biochemistry of Food and Nutrition* by Mehas and Rodgers.

c. Complete the lab **Effects of Heat on Making a Solution: Lemonade**.

d. Execute the lab **Effects of Solutes on Freezing and Boiling Points**.

Assessment

Paper and Pencil

1. Write lab reports for each laboratory experiment.

Classroom Experiences

1. Discuss the questions provided with the laboratory experiments.

Application to Real-life Settings

1. Complete the **Concentrated Foods** activity sheet.

Laboratory Experiment

Effects of Heat on Making a Solution: Lemonade

NAME_____ DATE_____ CLASS PERIOD_____

INTRODUCTION

When molecules separate from each other and spread out or diffuse into a solvent, dissolving is taking place. One factor which affects the rate of dissolving is temperature. Most solids will dissolve better in warmer liquids, although this is not always the case. Molecules in a solid are close together and have minimal movement. They are said to have strong cohesion. Cohesion is the attraction like molecules have for each other. Heat weakens cohesion between molecules by causing molecules to move faster and spread further apart. Thus, the dissolving process is speeded up. Another type of inter-molecular attraction related to dissolving is adhesion. Adhesion is the attraction of one kind of molecule for another kind of molecule. If molecules of a solute are attracted to molecules of the solvent, dissolving takes place. In this lab, you will observe the effects heat has on making a solution.

PROCEDURE

1. Place 2 sugar cubes into each of three glasses that have been labeled *boiling, room temperature* and *cold.*
2. Place a thermometer into each glass. Water will be used as the solvent. Prepare water at each of the following temperatures, and add slowly to the appropriate glass; record the temperature (DO NOT STIR):
   a. 250 mL boiling water
   b. 250 mL room temperature water
   c. 250 mL cold water.
3. Which temperature dissolved the sugar cube first? Next? Last? Record your findings.
4. Add 30 mL of lemon juice to each glass. Stir the mixture. Add ice and sample the sweetened lemonade; record your findings.

Laboratory Experiment

NAME_____ DATE_____ CLASS PERIOD_____

DATA TABLE: Effects of Heat on Making a Solution: Lemonade

Water Treatment	Temperature	Rate of Dissolving	Observations and Comparisons
Boiling			
Room Temperature			
Cold			

Lemonade: Observations and Findings

CLEAN-UP INSTRUCTIONS

(Provided by the teacher)

QUESTIONS & CONCLUSIONS

1. Explain the effects of temperature on the dissolving rate of solids in liquids.
2. Why is it easier to dissolve sugar into hot tea than iced tea?
3. What was the solute in this experiment?
4. Give examples of molecules that do not mix.
5. Explain the difference between adhesion and cohesion.

For Teacher Use - Effects of Heat on Making a Solution: Lemonade

TIME: 1 hour

SAFETY PRECAUTIONS: **Explain the following safety precautions to students before proceeding with this lab.**

Electrical Safety-Handle electrical equipment with dry hands; plug and unplug with care.

Clothing Safety-Wear an apron to protect clothing.

Fire Safety-Use caution when heating water.

Hand Safety and Protection-Use hot mitt/pad.

Glassware Safety-Handle thermometers and other glassware with care; thermometers must be free of chemicals (used only with foods).

Personal Hygiene Safety-Use sanitary practices throughout this experiment.

Equipment Use and Safety-Handle and use equipment properly and with care.

Materials and Equipment Needed		
6 sugar cubes 90 mL (or 6 Tbsp.) of lemon juice	3 glasses graduated cylinders (or measuring spoons) spoons for stirring and tasting	thermometers (for food use only) heat source ice food coloring (optional)

ANSWERS TO QUESTIONS AND CONCLUSIONS

1. Temperature increases the dissolving rate of most solids in liquids.
2. Heat speeds the dissolving rate of most solids in liquids.
3. Sugar.
4. Grease and water, oil and water, flour and water.
5. Adhesion is when one kind of molecule is attracted to another kind of molecule. Cohesion is the attraction like molecules have for one another. When sugar dissolved, it seemed to disappear; it did not. The molecules had simply dissolved and diffused among the water molecules. The molecules traded cohesion for adhesion.

Teacher Note: Use food coloring in the water to show diffusion.

Adapted from *The Science Cookbook*, pp. 5-6.

Laboratory Experiment

Effects of Solutes on Freezing and Boiling Points

NAME_____ DATE_____ CLASS PERIOD_____

INTRODUCTION

A pure substance has a definite freezing point and a definite boiling point dependent upon the atmospheric pressure. The addition of a solute to a pure water will change its freezing and boiling points. Determine the effect of freezing and boiling points of pure substances when a solute is added.

PROCEDURE

1. Fill a beaker with 100 mL water; place beaker on a hot plate/burner set at medium high. (CAUTION-Use metal trivet on burner, be sure thermometer is in liquid and not touching bottom of container, as this may give a false reading)
2. Place a thermometer in the heating water. When the water has reached a full boil, record its temperature in your data table.
3. Add ice to the second beaker until it is about half full. Add water to the beaker to the same level as the ice.
4. Place a thermometer in the ice water mixture for 3-4 minutes. After that time period, record the temperature of the ice water in your data table.
5. Weigh 5 grams of table salt (NaCl).
6. Slowly add the 5 grams of salt to the beaker of boiling water. Stir until all of the salt has dissolved.
7. Continue heating the salt water until it reaches a full boil again. Read the temperature again and record on the data table.
8. Repeat Step 5, and add the 5 grams of salt to the ice water.
9. Stir until all of the salt has dissolved, and record the temperature of the ice water with the 5 grams of salt.
10. Weigh an additional 5 grams of salt for each beaker.
11. Add the additional 5 grams to the boiling water and repeat Steps 6 and 7 for the boiling water with a total of 10 grams of salt.
12. Add the other 5 grams of salt to the ice water, and record the temperature for the ice water with a total of 10 grams of salt.
13. Freeze samples (100 mL each) of pure water, water with 5 grams of salt, and water with 10 grams of salt. Read temperatures of each sample; record the results.

Laboratory Experiment

NAME_____ DATE_____ CLASS PERIOD_____

DATA TABLE: Effects of Solutes on Freezing and Boiling Points

Treatment	Freezing Point	Boiling Point
Pure Water		
Water + 5 g salt		
Water + 10 g salt		

CLEAN-UP INSTRUCTIONS

(Provided by the teacher)

QUESTIONS & CONCLUSIONS

1. What happens to the freezing point of a liquid when a solute is added?
2. What happens to the boiling point of a liquid when a solute is added?
3. Why is rock salt added to the ice when making homemade ice cream?
4. Why might you add salt to a pot of water if you wanted to cook spaghetti?
5. The freezing point of pure water is zero degrees Celsius and the boiling point of pure water is 100 degrees Celsius. Why might your experimental freezing and boiling point of pure water have been different?

For Teacher Use - Effects of Solutes on Freezing and Boiling Points

TIME: 1 Hour

SAFETY PRECAUTIONS: **Explain the following safety precautions to students before proceeding with this lab.**

Electrical Safety-Handle electrical equipment with dry hands; plug and unplug with care.
Eye/Vision Safety-Wear goggles for eye protection (thermometers can explode).
Fire Safety-Use caution with heat source and hot water.
Hand Safety and Protection-Use hot pad/mitt.
Glassware Safety-Handle thermometers and other glassware with care.
Equipment Use and Safety-Handle and use equipment properly and with care.

Materials and Equipment Needed		
two 400 mL beakers thermometer	heat source table salt (NaCl)	ice water

ANSWERS TO QUESTIONS AND CONCLUSIONS

1. The freezing point is lowered.
2. The boiling point is higher.
3. Salt lowers the freezing point allowing ice cream to freeze.
4. Solutions such as water with salt added have a higher boiling point. Even though it takes longer for the water to reach the higher boiling point, the spaghetti will cook more quickly.
5. Tap water was most likely not pure; may have contained some minerals.

Source: *Food Science Experiment and Activity Guide.* ***Raleigh, NC:*** North Carolina Department of Public Instruction, 1994.

Activity Sheet

CONCENTRATED FOODS

NAME_____ DATE_____ CLASS PERIOD_____

List products that are concentrated to increase shelf life, lower cost, improve ease of transportation, and require less storage space. An example of each is listed below to help you get started.

Dry Goods	Refrigerated	Frozen
e.g., Tomato paste	e.g., Soup bases	e.g., Eggs

For Teacher Use - Concentrated Foods

Possible responses to "Concentrated Foods" Activity Sheet.

Dry Goods	Refrigerated	Frozen
Tomato paste	Soup bases	Eggs
Fruit juice	Concentrated flavorings	Fruit juices
Dry milk	Gravy mixes	Vegetables
Dry salad dressings	Jams	Fruits
Dry soup mixes	Eggs	
Pasta		
Spices		
Seasonings		
Vegetable oils		
Coffee		
Syrups		
Flavorings		
Sweetened condensed milk		
Evaporated milk		
Molasses		
Potatoes		
Tea		

Module 9 Overview

Practical Problem:

What roles do food additives play in food processing?

Competency:

F9 Identify the classes of food additives.

Supporting Concepts:

1. Classes of food additives

Teacher Background Information

Rationale

Food additives can be divided into classes based on their function. The specific food, the desired results, cost and regulatory issues help determine which food additive to use.

Background

There are several different classes of food additives. Linsey (1996) divided the additives into the following nine groups: "processing additives; pH control and modification agents; final product additives; appearance and control agents; flavor and flavor modifiers; nutrient and dietary supplements; sequestrants (chelating agents); specific gravity control agents; surface tension control agents; sweeteners; texture and consistency control agents."

1. Processing additives consist of aerating and foaming agents; antifoam agents; catalysts; clarifying and flocculating agents; color control agents; malting and fermenting aids; oxidizing agents; freezing and cooling agents; and material handling aids.
2. pH control and modification agents are acids; bases; buffering salts; release and antistick agents; sanitizing and fumigating agents; separation and filtration agents; solvents, carriers and encapsulating agents; and washing and surface removal agents.
3. Final product additives are antimicrobial agents and antioxidants.
4. Appearance control agents are color agents or other agents which can make the appearance glossy, polished or glazed.
5. Flavor and Flavor Modifiers provide flavor or enhance the flavor.
6. Nutrient and dietary supplements include amino acids, vitamins, minerals and fatty acids.
7. Sequestrants (chelating agents) are metal ions that form a complex which stabilizes the food.
8. Specific gravity control agents are substances that change the density of the food product.
9. Texture and consistency control agents are emulsifiers and emulsifier salts; firming agents; leavening agents, masticatory substances; propellants; stabilizers and thickeners; texturizers and tracers.

Many of these have more than one function and therefore appear in more than one class. Examples of each of these classes are listed on the **For Teachers Use** pages at the end of this module.

References

Fennema, O.R. Food Additives in *Food Chemistry* (R.C. Lindsay), New York: Mercel Dekker, 1996. 812-821.

Learning Activities

1. **Classes of Food Additives**

   a. Using the chart on p. 344, in *Food Science: The Biochemistry of Food and Nutrition* by Mehas and Rodgers, place each of the food additives listed into one or more of the nine classes identified by Linsey.

   Discussion Topics:

   What is the significance of these classes?

   Why would a food contain different classes of additives?

   b. Using different food items, discuss which food additives each contains.

   Discussion Topics:

   Identify the food additives that are present.

   Which classes do they belong in?

   Describe the function of each additive in that product.

   c. Select three food products from the kitchen. List the product and all of its ingredients. State which ones are food additives, the class each belongs in, and their function is in the product.

   Discussion Topics:

   Identify the food additives that are present.

   Which classes do they belong in?

   Describe the function of each one in that product.

   d. Choose a complicated recipe such as beef stroganoff. List the ingredients in order by weight or volume.

   Discussion Topics:

   Which of the ingredients are additives?

   Which class does each additive fall into?

   e. Compare foods with and without synthetic additives. (Foods without additives can be located in the health food section of a grocery store, e.g., peanut butter) Taste these products and compare the texture, odor and color.

   Discussion Topics:

   Which food additives are present?

   Why were these additives added?

   Could you tell a difference between the two products?

   Which product did you prefer?

Assessment

Paper and Pencil

1. Write a lab report on how foods without additives differ from those with additives.

Classroom Experiences

1. Compare and examine foods with and without additives. Refer to the charts **Classes of Food Additives** for examples of food additives in addition to those listed in the text.

Application to Real-life Settings

1. Given a label from a food product, identify the food additives present, the additive class each belongs to, and its function.

For Teacher Use - Food Additives

The following chart identifies the classes of Food Additives used on page 344 of the Mehas and Rodgers text. This information may be useful in solving Learning Activity 1.

Classes of Food Additives	**Additives**
Processing Additives	Calcium silicate, Potassium nitrite, Silicon dioxide, Sodium nitrate
pH Control and Modification Agents	Acetic acid
Final Product Additives	Acetic acid, Ascorbic acid, BHA, BHT, Calcium propionate, Potassium sorbate, Propionic acid, Propyl gallate, Sodium propionate, Sorbic acid, Tocopherols
Appearance Control Agents	Azodicarbonamide, Benzoyl peroxide, Beta-carotene, Potassium nitrite
Flavors and Flavor Modifiers	Mannitol, MSG, Sodium chloride, Sorbitol, Vanillin
Nutrient, Dietary Supplements	Beta-carotene, Biotin, Potassium iodide, Tocopherols
Sequestrants	Sodium citrate, Tartaric acid
Sweeteners	Sorbitol, Sucrose, Xylitol
Texture and Consistency Control Agents	Ammonium alginate, Calcium alginate, Carob bean gum, Carrageenan, Guar gum, Mannitol, Sodium alginate, Sodium citrate, Tragacanth gum

Source

Mehas, K.Y. and Rodgers, S.L. *Food Science: The Biochemistry of Food and Nutrition.* 3rd ed., New York: Glencoe/McGraw-Hill, 1997. 344-345.

Fennema, O.R. *Food Additives in Food Chemistry* (R.C. Lindsay), New York: Mercel Dekker, 1996. 812-821.

For Teacher Use - Additional Food Additives

The following chart classifies additional additives not listed on page 344 of the Mehas and Rodgers text.

Classes of Food Additives	Additives
Processing Additives	Carbon dioxide, Mineral oil, Rennin, Gelatin, Magnesium chloride, calcium phosphate, starches, and hydrogen peroxide
pH Control and Modification Agents	Lactic acid, Sodium bicarbonate, Sodium potassium tartrate
Final Product Additives	Benzoic acid and Sulfite
Appearance Control Agents	Beet powder, Beeswax, and Oleic acid
Flavors and Flavor Modifiers	Herbs, Spices, and Sodium chloride
Moisture Control Agents	Glycerine, Mannitol, Sorbitol
Nutrient, Dietary Supplements	Aspartic acid, Lysine, Boric acid, Niacin, and Linoleic acid
Sequestrants	Citric acid and potassium citrate
Specific Gravity Control Agents	Brominated vegetable oil
Surface Tension Control Agents	Sodium phosphate and Ox bile extract
Sweeteners	Aspartame, Glucose, Saccharin, and Sorbitol
Texture and Consistency Control Agents	Lecithin, Calcium carbonate, Sodium bicarbonate, Paraffin, Carbon dioxide, Pectin, Mannitol, Titanium dioxide

Source

Fennema, O.R. *Food Additives in Food Chemistry* (R.C. Lindsay), New York: Mercel Dekker, 1996. 812-821.

CE 076 531

Name: _____

Food Science 40-5300-C

(Family and Consumer Sciences)

Course Rationale:
To improve the health and quality of life of Missouri citizens, performance competencies for the Food Science course taught in Family and Consumer Sciences Education programs enable students to:

a. construct meaning related to the biochemistry of foods and nutrition;
b. solve problems related to foods and nutrition through the application of scientific principles; and,
c. assess the impact of food safety and sanitation on the health and well-being of individuals and families.

Directions:
Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
3 Mastered - can work independently with no supervision
2 Requires Supervision - can perform job completely with limited supervision
1 Not Mastered - requires instruction and close supervision
N No Exposure - no experience or knowledge in this area

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3	2	1	N	A. Orientation to Food Science
				1. Compare and contrast food science to foodservice management
				2. Utilize basic principles of measurement in scientific experimentation (e.g., metrics, formulas, and equations)
				3. Demonstrate use, care, and safety of scientific lab equipment
				4. Explain the steps in the scientific method
				5. Write accurate and complete reports of science experiments
				6. Identify the public and private organizations that influence food science, dietetics and nutrition industries
				7. Identify career paths related to food science, dietetics and nutrition
				Other:

3	2	1	N	B. Sensory Evaluation of Food
				1. Identify qualities that make up the sensory characteristics of food
				2. Describe characteristics of sensory evaluation using appropriate terms
				3. Determine characteristics that affect food preferences
				Other:

3	2	1	N	C. Food Safety and Sanitation
				1. Compare the positive and negative effects of yeast, molds, bacteria and enzymes in foods
				2. Identify principles of HACCP (assess hazards, identify critical control points, set up control procedures, monitor critical control points, take corrective actions, develop a record keeping system, verify that the system is working)
				3. Describe the types of microorganisms that cause foodborne illness (e.g., bacteria, viruses, parasites, yeast, molds)
				4. Explain the relationship between microorganisms and foodborne illness
				5. Describe the basic environmental conditions that encourage the growth of microorganisms (e.g., time, temperature, moisture, oxygen)
				6. Identify the three major types of hazards that cause foodborne illness (biological, chemical and physical)
				7. Describe symptoms and causative agents of major foodborne illnesses (e.g., salmonellosis, botulism, hepatitis A)
				8. Discuss how contamination and cross-contamination of foods can occur
				9. Identify methods and procedures for controlling foodborne illness
				10. Demonstrate personal hygiene/health practices essential for food safety and sanitation
				11. Name typical products, tools and methods for effective cleaning and sanitizing
				12. Identify location of and information on MSDS (Material Safety Data Sheets)
				Other:

3	2	1	N	D. Science Foundations
				1. Demonstrate the effects of acids and bases in food metabolism, preparation, processing and preservation
				2. Describe the classes of matter, including pure substances and mixtures
				3. Identify the elements found in biochemical systems (food) and their atomic symbols
				4. Explain the properties and principles of matter and energy (e.g., bonding, parts of the atom)
				5. Identify components of a chemical equation
				6. Differentiate between chemical reactions and physical changes in food
				7. Demonstrate the relationship between energy, physical changes, and chemical reactions
				8. Discuss the relationship between molecular motion and temperature
				9. Explain how heat is transferred
				10. Interrelate the effects of temperature, latent heat and phase changes
				Other:

3	2	1	N	E. Biochemistry of Foods and the Major Nutrient Groups (Carbohydrates, Proteins, Lipids, Vitamins, Minerals and Water)
				1. Describe terms related to the major nutrients and nutrient groups
				2. Describe the functions of the major nutrients and nutrient groups
				3. Explain the functions of the major nutrients and nutrient groups in foods and food systems

3	2	1	N	E. Biochemistry of Foods and the Major Nutrient Groups (Carbohydrates, Proteins, Lipids, Vitamins, Minerals and Water) (continued)
				4. Explain the process of sugar hydrolysis
				5. Identify the product resulting from the hydrolysis of sucrose and lactose
				6. Compare the structures of amylose and amylopectin and their effect on cooking properties
				7. Discuss gelatinization, paste, retrogradation and syneresis as they relate to starch cookery
				8. Explain what occurs during denaturization
				9. Describe the chemical structure of protein
				10. Compare the properties of saturated and unsaturated fatty acids
				11. Identify foods that contain saturated and unsaturated fats (triglycerides)
				12. Explain the differences between the types of fats and cholesterol
				13. List the ways lipid oxidation can be controlled in food
				14. Explain the role of water in the formation of solutions, colloidal dispersions and emulsions
				15. Compare and contrast bound and free water in foods
				16. Compare and contrast water soluble and fat soluble vitamins
				17. Distinguish between major and trace minerals
				18. Identify some interrelationships among nutrients (e.g., vitamin D and calcium)
				19 Discuss the effect of food processing on vitamin and mineral levels in food
				20. Relate metabolism to the factors that affect it
				Other:

3	2	1	N	F. Chemistry of Food Formulations and Reactions
				1. Explain the relationships between enzymes, coenzymes and substrates
				2. Identify factors that affect enzymatic activity
				3. Distinguish the function of enzymatic reactions in food spoilage and food preparation
				4. Identify the solvents and solutes in solutions
				5. Analyze the effect of concentration on physical properties of a solution
				6. Identify the properties of colloidal dispersions
				7. Explain the relationship of an emulsion's parts
				8. Explain the functions and properties of leavening agents
				9. Identify the classes of food additives
				10. Discuss the role of governmental regulations regarding food additives
				11. Explain the use of additives in food
				12. Discuss the risks and benefits of using additives in food
				Other:

3	2	1	N	G. Food Manufacturing Processes (Fermentation, Canning, Freezing, Dehydration and Irradiation)
				1. Define terms related to food manufacturing processes
				2. Identify commonly processed foods
				3 Compare and contrast food manufacturing processes
				4 Identify equipment used in food manufacturing processes
				Other:

Notes:

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